METALLURGIA

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Non-ferrous Metal Production in Canada

Important Improvements in Metallurgical Practice.

The trend in base-metal production in Canada is towards more complete recovery of the metal in the ores, increased operating efficiencies, and consequently lower costs, in all of which eminent success has been attained. The closer union of Great Britain and the Dominions brought about by the Ottawa Conference has greatly strengthened the marketing situation ; and in view of the low production costs attained and the large ore reserves available, Canada will continue to supply its full share of the world's requirements in base metals.

THERE is every indication that Canada is well on the road to industrial recovery. Her condition is, no doubt, largely due to the revival in demand for those products she is able to supply from her great natural resources, but several factors have also contributed to the healthier trend, not the least of which have been the nation's own efforts. The general improvement in world conditions has naturally shown a sharp reflection in Canada's trade, industry, and business, while the agreements reached at the Ottawa Conference have done much to facilitate the marketing of her products ; these advantages however, valuable though they are proving to be, would have been futile had not the nation sought to adjust herself to the new conditions resulting from the world depression, by the application of scientific methods and sound, constructive policies for the development of her resources. Certainly, the very marked improvement in Canada's primary industries, in a large measure, is due to this factor. Many problems still remain to be solved, but recent achievements have been substantial. The extension of the Canadian industries has been the outstanding development in recent years in Canada's economic situation, and the progress has not been alone in physical development, but has included important improvements in metallurgical practice, and in this article it is proposed to review briefly the metal production industries giving primary consideration to the base metals.

Probably the most outstanding feature in Canada's recovery is the remarkable expansion of her gold mining industry. The higher price for the metal has improved the outlook for large deposits of low-grade ore, which are practically assured of successful operation. Further, the presence of gold in association with the base metals has aided the production of the latter, and has enabled some of Canada's base-metal producers to continue their operations with much more favourable results than would have been possible otherwise. But while public interest has been attracted by gold-mining developments, there has been a tendency to overlook important work which has been done in other branches of the mining industry ; in most metals, for instance, output has sharply increased. Canada's position as a producer of nickel, zinc, and lead is fully maintained and as a producer of copper it is further improved.

Flin Flon Mill, Smelter and Zinc Refinery, which was constructed and power plant put into operation in less than two years. It presents one of the most outstanding developments in the Canadian mining industry.

As is well known, the nickel produced in Canada has its source almost entirely in the nickel-bearing ores of the Sudbury district in Ontario. The known reserves of nickel ore in this district are by far the largest in the world, being estimated at over 200,000,000 tons, carrying perhaps, on the average, about 3% nickel and 2% copper, though the grade varies greatly in different mines. Ore from Creighton mines, for example, carries about 5% nickel, while some of the ore in the lower levels of the Frood mine carries as much as 20% copper. The largest individual ore body—that of the Frood—has been only partly explored as yet, but over 125,000,000 tons of ore are already indicated. Production and developed reserves in this district are entirely in the hands of two companies, International

General view of Trail Smelter of Consolidated Mining and Smelting Co., constructed to deal with the ores from the Sullivan mine in British Columbia.

during the latter part of 1933, and the outputs of copper, lead, and zinc for the year as a whole were all in excess of those of 1932—copper approximately 21%, lead 3%, and zinc 15%. The increased activity in evidence at the end of 1933 has continued into 1934.

In Eastern Canada the Noranda mine in Quebec produced some 2,000,000 lb. more copper than in 1932. During the year concentrator capacity was increased from 1,500 to 2,000 tons of ore a day, and is now being further increased to 3,000 tons a day. For the time being, however, the chief efforts at this mine are being directed to increasing the gold rather than the copper output. Noranda's subsidiary, Waite Amulet Mines, was idle throughout the year. The copper refinery at Montreal, controlled by the Noranda Co., operated somewhat under capacity. An addition is being made to this plant for the recovery of selenium and tellurium as by-products.

Nickel Co. and Falconbridge Nickel Co. The former is the larger, being capable of mining, concentrating, and smelting 8,000 tons of ore per day; the capacity of the Falconbridge company's plant is now nearly 800 tons of ore per day.

During the worst of the depression, the plant of International Nickel Co. was operating at about 20% capacity; to-day, however, it is working nearer 50% of plant capacity, while the Falconbridge Co.'s plant has been operating at full capacity for over a year. While this notable revival of the nickel mining, smelting, and refining industry can be attributed largely to a general quickening in industrial activity, a second important factor is a growing familiarity with, and confidence in, nickel alloys in engineering.

It is noteworthy that the Falconbridge Co. treat the ore in a blast-furnace, when most other smelters throughout the world use the reverberatory furnace. The medium-grade ore at Falconbridge, being higher in nickel than in copper, and possessing a high sulphur content, is found to be peculiarly suited to smelting in the blast-furnace. By using the sulphur as fuel, the percentage of coke required is kept as low as 8% of the weight of the charge. Though there are a number of influences that might upset the balance in this type of smelting, by keeping within certain limits there is achieved at Falconbridge a better recovery of the metals and lower costs than would be possible by the alternative methods, and this in spite of the fact that the capital cost of the requisite plant is also considerably less. Recently this company installed a concentrating and sintering plant to treat low-grade ore, which formerly was either left in the mine or was treated in the smelter at a cost higher than its metal content warranted. By taking out three-quarters of the barren rock material of this low-grade ore, the feed for the blast-furnace has been made much richer in metals than it was formerly, so that to-day the smelting plant, with only slight additions, is able to treat 780 tons of ore, against a former 545 tons.

A further notable advance is achieved by the addition to plant at Montreal East of Canadian Copper Refiners, Ltd., a subsidiary of Noranda Mines, Ltd., by which selenium and tellurium are now being produced in the Dominion for the first time. With regard to the production of copper, lead, and zinc in Canada, the following report, prepared by A. H. A. Robinson,* is published with the permission of the Deputy Minister, Department of Mines, Ottawa, which is both interesting and informative :—

Copper, Lead, and Zinc in Canada.

In response to increased metal prices, there was a corresponding increase in base metal production in Canada

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The copper output of International Nickel Co. at Sudbury, Ontario—Canada's largest copper producer—though greatly curtailed during the first three months of 1933, increased rapidly during the last three quarters of the year; total sales amounting to 113,682,312 lb., or 97% more than those of 1932. Operations at International's subsidiary, the Ontario Refining Co., were increased from 4,000 tons of blister copper per month at the beginning of the year to 6,500 tons a month during the last quarter. At Falconbridge Nickel Mines, also in the Sudbury District, Ontario, the copper output increased from 2,394,000 lb. in 1932 to 4,206,000 lb. in 1933. Corresponding increased capacity was also made to the company's refinery, which is in Norway. It might be noted that the rate of copper production by both the International and Falconbridge companies is dependent on the demand for nickel, not copper, nevertheless both report a satisfactory outlet for all the copper produced.

In the middle west, the Hudson Bay Mining and Smelting Co.'s Flin Flon mine and smelter in Manitoba operated at capacity continuously throughout the year, producing 41,148,717 lb. of blister copper, as against 42,371,629 lb. in 1932—a slight falling off. Blister copper from Flin Flon, like that from Noranda Mines, is refined by the latter company's subsidiary, Canadian Copper Refiners, Ltd., at Montreal East, Quebec. The Sherritt-Gordon mine, situated about 40 miles north of the Flin Flon, and like the latter a copper-zinc mine, remained idle throughout the year.

In British Columbia the Granby Consolidated's Hidden Creek mines and Anyox smelter operated throughout the year, producing 34,459,581 lb. of copper, as compared with 38,648,820 lb. in 1932. The blister copper produced is shipped to the United States for refining in bond, and is sold abroad. According to the Company's last annual report, ore reserves at the Anyox mines will be exhausted in about two years' time at the present rate of extraction. The Company's Copper Mountain mine in southern British Columbia, is still closed down. Known ore reserves at Copper Mountain amount to nearly 10,000,000 tons, but are too low grade to be worked profitably at the present price of copper. At Britannia mines, British Columbia's second largest copper producer, operations were greatly curtailed; but as the price of copper and gold rose during the year output was increased. At the end of the year, however, production was still only about 20% of normal

capacity. Britannia's copper is all shipped in concentrates to the United States to be smelted and refined in bond.

Over 96% of Canada's lead and about 70% of its zinc is produced in British Columbia by the Consolidated Mining and Smelting Co. In 1933, Consolidated produced 254,639,548 lb. of lead and 137,619,895 lb. of zinc, as compared with 253,237,783 lb. and 130,567,785 lb. respectively in 1932. All of this is marketed as electrolytically refined metal. Costs of production of both lead and zinc were reduced to a record low level and at the same time recoveries in concentration and smelting were the highest on record. Canada's next most important zinc producer, the Hudson Bay Mining and Smelting Co.'s Flin Flon mine in Manitoba, also operated throughout the year, producing 46,305,736 lb. of electrolytic zinc, as against 41,736,600 lb. in 1932. The grade of this company's output, already exceptionally high—was further slightly improved during the year, averaging 99·9894% zinc. A certain amount of die-casting zinc, 99·9+% pure was also made. At the same time, the operating efficiency of the plant was improved. A new producer of zinc in Canada in 1933 was the Britannia copper mine, where, due to an unsatisfactory market for their copper concentrates, the mill has been altered to produce a zinc concentrate also. Temporarily, the output of zinc concentrates at Britannia is of greater bulk—but not value—than of copper concentrates. Britannia mine has an enviable record for low production costs. The concentrates produced are shipped to the United States for smelting and refining in bond.

The Noranda Smelter of the Noranda Mines Ltd., Quebec.

The present trend in Canadian base metal production is towards more complete recovery of the metal in the ore, increased operating efficiencies, and consequently lower costs, in all of which eminent success has been attained. Though the markets of our neighbour to the south—the United States—are closed to Canadian copper, lead, and zinc by impassible tariff barriers, on the other hand, the closer union of Great Britain and the Dominions brought about by the Ottawa Conference, has greatly strengthened the marketing situation; so that in view of the low production costs attained and the large ore reserves available, Canada should be able to continue to supply its full share of the world's requirements of base metals at a reasonable profit.

This report indicates that in spite of the difficulties which low prices have imposed on development of new mining properties, Canada has continued to improve her position as a producer of copper and lead, while retaining her dominance as a source of nickel. Canadian producers of copper have continued to operate, and substantial progress has been made by Noranda Mines, Ltd., in Quebec, and the Hudson Bay Mining and Smelting Co., Ltd., at Flin Flon, Manitoba, these companies having been assisted by the gold content in their ore. Exports of Canadian copper have been increased, and further expansion is considered to be assured.

Some of Canada's important Mines.

Romantic stories could be written of each of Canada's mines, in which enterprise and resourcefulness of pioneers would predominate. The Consolidated Mining and Smelting Co., for instance, was a very small company until about 25 years ago, when it acquired the property known as the Sullivan mine. This permitted the subsequent phenomenal growth of the company. The ore deposit in this property was of huge dimensions, and its combined gold, silver, lead, and zinc made the ore unusually rich. In the early days only a very small part of this ore was amenable to the methods of treatment then in use, the larger part being so complex that it was impossible to separate the constituent metal economically. Long and arduous work was involved on the problem of putting this huge reserve of ore to use. The discovery of the flotation process was a great aid; but effective work was accomplished by the Trail metallurgists, and the processes they developed have been mainly responsible for the remarkable advances made in the treatment of the Sullivan. So perfect has the series of process now become that gold, silver, lead, zinc, sulphur, cadmium, bismuth, and even copper are now recovered. Iron is probably the only potentially valuable ingredient of the ore that is not recovered, and even this the Trail metallurgists contemplate saving.

The Sullivan mine of the Consolidated Mining and Smelting Co. is in British Columbia, and it is contributing the bulk of Canada's production of lead and zinc. Concentrates are produced from the ore at the mine at Kimberley, which are treated in the refinery at Tadanac. The concentrator at Kimberley has a capacity of 6,000 tons per day, while the electrolytic lead refinery at Trail has a capacity of 475 tons of refined lead per day. In recent years the capacity of the zinc plant at Trail has been increased by the completion of a new slag-fuming plant, which recovers the zinc formerly lost in the slag from the lead furnaces. Recent additions to the plant have increased the capacity of the works to about 400 tons of zinc per day. It can be safely stated that only splendid organisation,

Aerial view of the Copper Cliff Refinery of the International Nickel Co. of Canada, in Ontario.

technical efficiency, and corporation loyalty of the Consolidated Mining and Smelting Co., of Canada, have made possible its phenomenal development in the face of extreme difficulties, which not only concerned metallurgical problems but the market situation and adverse conditions of monetary exchange.

The Horne mine at Noranda is another of considerable interest. It is one of the richest of the world's large mines, and is just about ten years old. It has been opened up to

Britannia Mill and Cable Tramway, Britannia Beach, British Columbia.

a depth of half a mile and an immense amount of ore has been determined. No fewer than twenty-five bodies of ore have been found, and others are being located gradually as more ground is explored. Among these numerous bodies of ore there is a considerable variety, some being high in copper and low in gold, some the reverse, and still others between the two extremes; moreover, the rock constituents of the ore vary in such a way that a mixture can be obtained for the smelter that permits of treatment at the lowest possible cost and with the maximum recovery of the metals.

Manitoba has added a chapter to the romance of mining by the development of Flin Flon. Discovered in 1915 at a distance of ninety miles from the railway, huge in size, but low in grade and complex in its nature, the ore deposit remained unused for ten years. Scores of engineers examined it, and a number of substantial mining companies attempted to find a means of exploiting it, but it remained a tantalising possibility. In 1925, however, a course of development was begun which, for speed and thoroughness in a remote locality, is without parallel in Canada and possibly throughout the world.

The first task was to check the tonnage and grade of the Flin Flon ore, to find a method of separating out the gold, silver, copper, and zinc it contained, and to locate water near at hand that would provide the requisite cheap power. By the summer of 1926 these three points had been sufficiently determined to warrant the erection of a 25-ton pilot mill on the property. This worked so well that by the end of 1927 it was decided to complete the purchase of the property, instal a plant of 3,000 tons daily capacity, and build a 44,000 h.p. power plant. Hudson Bay Mining and Smelting Co. was organised to finance the undertaking. The mine, it should be borne in mind, was still ninety miles from the railway, and the power site sixty miles still further on.

The construction of a 3,000-ton mill, a copper smelter, a zinc refinery, and a full-sized town at the mine was largely accomplished before the eighty-seven mile spur-line from the Hudson Bay Railway was available for use. The thousands of tons of materials and equipment required for this were brought in by tractor trains over the winter roads. Similarly, 36,000 tons of materials and machinery required for a 44,000-h.p. power plant at Island Falls was moved in by tractor trains for a distance of sixty miles beyond the mine. It was a bold undertaking, without precedent in this or any other land, the magnitude of which can be grasped from the fact that it cost over $20,000,000. The difficulties faced and overcome were tremendous, and the results reflects credit on the high organising capacity and enthusiasm of those who carried out the work.

To-day the province of Manitoba is subsisting to a notable extent upon the wealth being produced at Flin Flon. While the town of 4,500 is isolated and self-contained, the company spends a large part of its income of over $7,000,000 a year in the province for wages and supplies. Its employees, numbering about 1,200, have been drawn mostly from residents of the province, and they have made excellent miners and operatives. It should be remembered that shortly after this mine had been developed, the mill, smelter, and zinc refinery constructed and the power-plant put in operation, the slump came, and the prices of copper, zinc, and silver went down to about half of what had been estimated originally. Instead of closing the mine until prices reached a reasonable level, an effort was made to improve processes and reduce costs; this was accomplished so successfully that even at these prices the mine operated at a profit. At present, with substantially improved prices and undiminished efficiency in the mine and plants, the mine is an outstanding success.

Many more mines could be mentioned, but sufficient has been said to indicate that the Canadian metal industry has entered a period of renewed activity, and plans were recently announced for the reopening of idle properties. Many, in fact, have reopened and are in operation, which is probably a better indication of the future trend than recent increases in production recorded.

Aluminium-clad Duralumin. "Alclad."

In the July issue reference was made to a recent development in the production of a particular material consisting of aluminium-clad Duralumin, which is marketed under a trade name. Some correspondence has been received regarding this reference, and in order that the information contained in the article may be given its true perspective, readers will appreciate that a material possessing all the properties referred to has been sold for some years under the trade name of "Alclad." This material is well known in the aircraft industry, particularly for seaplane work, and it has been fabricated at the Banbury Rolling Mills of Northern Aluminium Co., Ltd., since the opening of these works.

As far back as March, 1929, Air Ministry Specification D.T.D. 111 was drawn up and issued to cover the alloy generally known as "Alclad," and the mechanical properties quoted at the end of the article referred to are the minimum properties required to comply with the Air Ministry Specification mentioned.

Cold rolls of chilled cast iron, containing from 3–5% nickel and from 0·5–1·5% chromium, have given excellent results in the sheet and tin-plate mills of a Japanese steel works. The ordinary chilled iron rolls previously used had to be sent back to the lathe for re-turning after only a week's work with six hours' continuous operation each time, whereas the nickel-chromium cast iron rolls were usable, without re-turning, for forty or fifty days with twenty hours' continuous operation each time.

Exhaustive tests conducted by a machine tool manufacturer on two large boring machines, one having bronze bearings and the other antifriction bearings, revealed that the power saved by the full antifriction bearing machine amounted to over 25%. The builder has incorporated 93 ball bearings in this machine.

Corrosion Resistance of Metals in Wine Making

In a recent investigation on the effect of metals on wines it has been found that brilliance and/or colour are affected before any changes of flavour and bouquet are noted. Nickel and zinc have the least effect on colour.

IN the past wood has been favoured for the construction of winery equipment that could be conveniently made from it. In more recent years, from considerations of economy in cost and space and a desire to improve sanitary standards, some wineries have used tanks of concrete which are treated in some appropriate way or faced with some impervious material. With the development of corrosion-resisting metals, which are now available in the form of steel-clad plates, as well as in all the usual mill forms, the choice of materials available for the construction of winery equipment has been widened considerably. The metals offer important advantages over the old materials of construction. Probably the outstanding advantage is the ease with which such metal equipment can be cleaned and sterilised. Smooth, non-absorbent metal surfaces lend themselves to rapid cleaning and thorough sterilisation. With metal equipment, sterilising methods involving treatment of the surface only can be substituted for the older practice of burning sulphur to obtain penetration, thereby destroying micro-organisms within the body of wood as well as on the surface. The absorbed sulphur dioxide is subsequently assimilated by the wine.

The facility with which metal equipment may be switched from one kind of wine to another is a convenience, particularly when changing from red to white wines. All the coloured wine may be quickly washed from metal surfaces. The elimination of losses by leakage and of cooperage expense are also important. The strength of metals permits more efficient utilisation of tankage space, as much thinner tank walls may be used.

However, before any widespread application of metals may be undertaken in wineries, it is necessary to know how well the metals will resist corrosion by wine, and what effect, if any, the metals will have on the product. These two phases of the subject are closely related, as the metal that gets into the product is the result of corrosion. The metal or alloy that best fulfils the requirements will be one that possesses corrosion resistance in high degree, and is constituted of a metal or metals that have the least effect on the wine.

With this object, Messrs. H. E. Searle and F. L. La Qué have investigated the resistance of metals to corrosion by wine by placing metal samples in winery equipment where the metals were exposed to corrosion by wine under the actual operating conditions. In order that the effects of metals on wine might be studied, metal citrates were added to wines, and any changes that occurred were noted.

The metals that were included in the corrosion tests are shown in the table below. All specimens were cut from sheets as commercially supplied by the manufacturers. The tin samples were cut from sheets of pure tin (Straits grade), and not from sheets of tinned steel.

TYPICAL ANALYSIS OF METALS.
(In per cent.)

Metal.	Cu.	Ni.	Fe.	Cr.	Sn.	Al.
Aluminium 2S ..	—	—	—	—	—	99·0
Copper	99·9	—	—	—	—	—
Nickel	—	99·5	—	—	—	—
Tin	—	—	—	—	99·9	—
Monel metal	29	68	1·5	—	—	—
18-8 alloy	—	8	74	18	—	—
Inconel	—	80	6	13	—	—

In this investigation some 403 corrosion tests were made, and the tolerance of wines for metals was studied. The corrosion test data are used in estimating the probable pick-up of metals from equipment made of the metals, and this is compared with the tolerance of wines for the metals; over 125 samples were compared. Two metals (Inconel and 18-8 alloy) included in the corrosion tests were almost perfectly resistant under all the conditions studied. The results show that the pick-up of nickel, chromium, and iron from Inconel may be expected to remain under the tolerance of wine for these metals, even if the wine is processed entirely in equipment of this alloy. This indicates that Inconel is adequate for all winery uses. The pick-up of iron from 18-8 alloy storage tanks probably will exceed the tolerance of wines for iron, according to the date, and in two other stages of the process (closed fermenters and blending tanks) the tolerance for iron may be exceeded, but in all other stages of the process the alloy is adequate.

The data for nickel indicate that, because of the high tolerance of wine for nickel this metal may be used almost throughout the winery without affecting the colour, brilliance, flavour, or bouquet of wine. The data plainly shows that nickel may be used for bottling tanks, juice tanks, mixing tanks, and open fermenters. There is proof that these deductions are true, as nickel is in successful service in bottling tanks, pipe lines, juice tanks and juice pasteurisers.

The data also indicate that Monel metal, aluminium, and copper may be employed in certain winery equipment, such as juice tanks, in which the liquid does not remain for long periods. Wineries now use copper and copper alloys, aluminium, and Monel metal in pipe lines, pumps, filling machines, and the like. Tin is the only metal tested that appears to have a very limited application in wineries. Wine will tolerate only small quantities of tin, and the metal has a comparatively high corrosion rate, particularly when exposed to red wine under conditions of low aeration, which is the usual condition. It is self-evident that plain iron and steel are dangerous materials to use for any winery purpose that involves contact of these metals with wines that are being processed.

In this study of the effects of metals on wines, the authors find that brilliance and/or colour are affected before any changes of flavour and bouquet are noted. Only small quantities (3 mg. per litre) of iron and tin are required to induce objectionable changes of brilliance. Copper in much larger quantities has a slight effect on the brilliance of sweet red wine. None of the other metals affects brilliance. Aluminium, copper, and chromium have slight though not serious effect on colour. Nickel and zinc have the least effect on colour.

Results of a study of the behaviour of materials other than plain carbon steels for such use as coal and coke chutes at by-products coke plants leads to the general conclusion that chrome and chrome-nickel alloys withstand the combined action of water and sliding coal or coke abrasion much better than does plain carbon steel. Study of the data indicates that an alloy of 20% chromium and 1% copper is superior to chrome-nickel steels. Two 18–8 steels and a 27% chromium steel are next, followed by a steel containing 12 to 14 chromium and 0·12 carbon; one containing 16 to 18 chromium and 0·10 carbon; and one containing 12 to 14 chromium and 0.30 carbon.

1 *Ind. Eng. Chem.* 26, Ind. Ed. No. 6, 1934, 617-27.

Sintering of Iron Ores.

Equipment at the new Ford Works.

THE blast-furnace and coke-oven plant at the new Ford works at Dagenham is now in operation, and considerable interest attaches to the "Dwight-Lloyd" sintering plant for the treatment of iron-ore and blast-furnace dust. This has been supplied by Messrs. Huntington, Heberlein and Co., Ltd., of London, for a duty of 600–700 tons per 24 hours of sintered material ready for the blast-furnace, dealing with a mixture of Wabana, Benazif, and Bilbao ores, in addition to the blast-furnace flue dust. A similar installation has also just been completed at the new Corby steel works near Kettering.

The basic principle of sintering it will be remembered is to mix finely divided iron ore, and other raw material used for the blast-furnace, with solid fuel, generally coke breeze, and cause the mixture to travel on a long, horizontal, endless chain of flat carriages or "pallets," each having a flat floor of firebars. At one end the mixture is ignited by a gas-fired combustion chamber or ignition muffle, and the finely divided fuel is then burnt during the travel by means of air drawn through downwards into a system of suction wind-boxes and trunking connected to a powerful fan. As a result the ore is softened and agglomerates or sinters, giving large-sized porous grains of much improved quality for the blast-furnace.

In this Ford plant the approximate overall length of the machine is 71 ft. 0 in., while the travelling carriages or pallets are 6 ft. 0 in. wide, and the actual effective grate area approximately 310 sq. ft.

The ore will be grabbed from the stockyards and deposited in cars running on an elevated railway, discharging to a series of storage bunkers for the different kinds of ore; while the coke breeze from the adjoining "Wilputte" coke-oven plant, also now completed, will be stored in similar bunkers.

Beneath each of these bunkers is a variable-speed feed table, by means of which the ingredients are fed, in their proper proportions, on to a travelling band, the circuit including screens for removing any large-sized particles over $\frac{3}{8}$ in.

The material then goes into a rotary cylindrical mixer, into which will also be supplied the fines from the sintered material, as well as thickened blast-furnace flue dust from a "Dorr" filter, which forms part of the equipment. From this rotary mixer the product is taken to a high-level mixer by means of a series of inclined conveyors, and in this second mixer there is added a carefully regulated amount of moisture. As a result there is obtained an extremely intimate mixture of the iron ores, blast-furnace dust, and coke breeze, with also the correct amount of moisture.

The product is then fed on to one end of the travelling carriages of the sintering machine by a special "swinging spout" feed, which ensures uniform distribution over the whole 6 ft. 0 in. width, forming a layer 7–12 in. thick. The combustion chamber is to be operated with blast-furnace gas, taking 1,200–1,300 cub. ft. per ton of sinter, and at the end of the travel the carriages or pallets turn over as the endless chain goes round and back underneath on the return journey, tipping their charge of sinter on to a stationary screen.

The total power consumption will be about 15 kw.h. per ton of sinter, which includes the whole operation—that is, ore conveying, mixing, the fan drive for the wind-box circuit, combustion chamber blower, and all accessories, in addition to the sintering machine itself,—while also the total operating costs will be less than 2s. per ton of sinter.

Forthcoming Meetings

IRON AND STEEL INSTITUTE.

Sept. 10—13. The Autumn Meeting will be held in Belgium and Luxemburg by the kind invitation of Messrs. Léon Greiner and Aloyse Meuer, with the support and co-operation of the industrialists of those countries. The arrangements for the meeting have been carried out by influential reception committees, the hon. secretaries of which are Mon. A. Greiner (Belgium) and Mon. A. Kepgen (Luxemburg). The Sessions will take place at the Palais des Académies, Brussels, on Monday and Tuesday, September 10 and 11, and at the Hotel de l'Arbed, Luxemburg, on Thursday, September 13. The subsequent arrangements include visits and excursions to the principal iron and steel manufacturing and engineering establishments in Belgium and Luxemburg. The following papers are expected to be read and discussed:—

September 10: "Belgian Research Committee on the Behaviour of Metals at Elevated Temperatures," by H. Dustin; "Contribution to the Study of the Resistance to Chemical Attack of Various Special Steels," by A. Portevin, E. Pretet, and H. Jolivet; "Accelerated Cracking of Mild Steel (Boiler Plate) under Repeated Bending. Part II.—Further Tests," by C. H. M. Jenkins and W. J. West. If time permits: "Some Aspects of the Fatigue Properties of Patented Steel Wire," by E. T. Gill and R. Goodacre.

September 11: "The Influence of Silicon and Aluminium on the Resistance of Cast Iron to High Temperatures," by H. Thyssen; "Flexibility as a Factor in the Economic Exploitation of Rolling Mills and some Technical Means for its Realisation," by G. A. V. Russell; "The Physical Properties of Iron-Aluminium Alloys," by C. Sykes and J. W. Bampfylde. If time permits: "The Properties of Non-Hardenable Alpha-Iron Steels," by S. H. Rees.

Further papers to be presented at this meeting include the following: "The Influence of Vanadium on Carbon Steel and on Steels containing Nickel and Chromium," by H. H. Abram; "The Blistering of Iron Oxide Scales and the Conditions for the Formation of a Non-Adherent Scale," by R. Griffiths; "The Decomposition of Martensite," by Gunnar Hägg; "The Influence of Diffusing Elements upon the Alpha-Gamma Inversion of Iron," by W. D. Jones; "The Constitution of Iron-Rich Fe-Al-C Alloys," by F. R. Morral.

Arrangements have been made to enable members to visit many works in Belgium and Luxemburg.

INSTITUTE OF METALS.

Sept. 3—6. The Twenty-sixth Annual Autumn Meeting, to be held in Manchester, at which the Thirteenth Autumn Lecture will be delivered by Dr. J. L. Haughton on "The Work of Walter Rosenhain." This lecture will be given in the Great Hall, College of Technology, on September 3, at 7-30 p.m. The following papers are expected to be read and discussed:—

September 4: "The Improvement of White Bearing Metals for Severe Service: Some General Considerations," by D. J. Macnaughton; "The Behaviour of White Bearing Metals when Subjected to Various Deformation Tests. Part I.—Indentation Tests" (with an appendix on "An X-ray Examination of Babbitt Metal and of the Age-Hardening of Cast Lead-Alkali Alloy") by A. S. Kenneford, M.Sc., and Hugh O'Neill, D.Sc., M.Met.; "The Behaviour of White Bearing Metals when Subjected to Various Deformation Tests. Part II.—Tensile Tests," by R. Arrowsmith, B.Met., M.Sc.; "The Behaviour of White Bearing Metals when Subjected to Various Deformation Tests, Part

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TWENTY YEARS AFTER.

THE period of twenty years since the beginning of the Great War is regarded by the people of to-day as the most important in the history of the world: it may be that centuries hence it will not be regarded as a major event. Time gives mankind a truer perspective, and the world industrial revolution that has taken place in recent years is probably not more cataclysmic than many other changes in the affairs of man recorded in history. Be that as it may, the problems of a period have to be solved by the people living during that period, and it is better that the importance of the problems should be exaggerated rather than underrated.

The year 1914 was the end of an epoch. This country in particular had reached its zenith, and was, as the result of the courage and enterprise of its industrial and commercial pioneers, the first workshop of the world. Our markets were open and our industries were well managed. It was largely inherent qualities of character that were responsible for our leading position, and it is well to remember so to-day, when the whole world—except Britain—is in a ferment, and even economists here view the mechanisation of industry with alarm, as an accident that has occurred to interfere with the smooth unfolding of evolutionary processes. In 1914 the iron and steel industry and the non-ferrous metal industry were healthy and prosperous; the works were for the most part modern, the labour employed was skilled and well paid, and British goods were in demand throughout the world. International trading had few restrictions, and the carrying trade was largely in the hands of British shipowners, who, in turn, kept the shipbuilding yards busy, and these were the big customers of the iron and steel industry, and, in a lesser degree, of the non-ferrous industry.

Then came the war and all world industry was in the crucible. War is always an evil, and the Great War, because of its magnitude, has caused more commercial and industrial dislocation than any war of modern or mediæval times. Yet it is possible to regard it as a period of renaissance, in which a re-birth of industry has taken place. Technical progress was speeded up during the war years, and the process has gone on during the peace years since the Armistice. Research work has not had the degree of support it has deserved, but it is accepted as something that is essential to progress. The research associations have done extremely valuable work in this country in the past twenty years, and there are also the many research laboratories of firms that have been responsible for the discoveries of ferrous and non-ferrous alloys with physical properties that have rendered progress possible in engineering.

The present is the age of the technical engineer and the chemist. The perfecting of the lighter alloys has made possible the development of aviation, and has had an important bearing on general engineering design. Copper and aluminium alloys, in particular, are being used to-day for purposes for which they were unsuitable a few years ago: with heat-treatment their structure becomes homogeneous, their strength qualities are rendered high, they are are almost non-corrosive, and intensive research is being conducted that will render them of still greater practical value. There is no need for Britain to-day to regard itself as on a lower plane than any other country in regard to metallurgical science or engineering technique. It is satisfactory that the years of trade depression have not lessened the enthusiasm for research work, and it is this that is going to keep this country in the forefront despite the competition of those countries that have recently become industrialised. The metal industries need not regard the future as dark. Iron and steel are being used in new ways. The construction of buildings, for instance, is now largely an engineer's job, and non-ferrous metals are being more and more used for internal decorative purposes.

British industry is too critical and self-condemnatory. Perhaps it is well that it should be, but it is at least doubtful if the industries of other countries are better organised or more modernly equipped. The trade depression has quickened our perceptions and made us more introspective. The years 1914-18 proved the efficiency of our workshops, and since then there has been unceasing endeavour. There has been no tendency to be complaisant with things as they are. There has been much loose thinking and futile talk—we have all more or less indulged in it—about the need of certain industries putting their houses in order; actually those industries have had an urge to do so quite independently of any external pressure.

The war period was indeed a period of dislocation, and the stupendous job of readapting the heavy industries to mankind's requirements has necessarily been slow, and will take much time yet. Plant has been and is being modernised, small units have been welded together into vertical and horizontal combinations, the whole effect has been the desired one of cheapening production, and there has been a corresponding reduction of labour employed. There are those who believe that the economic balance will never be restored, but the social and economic problems the world is facing to-day will gradually be solved by natural forces. The world would regain 1914 prosperity more quickly were all restrictions on international trading to be abolished. The peoples of all countries are suffering because of tariff walls and embargoes of one kind and another. It is well to remember that the hatreds and jealousies created by four-and-a-half years of war will not be dissipated for some time yet.

What is the actual industrial position to-day? Twelve months ago trade was on the upgrade, but during the last four months the recovery appears to have been arrested. There has been no setback, but progress has certainly not been maintained at the rate of the previous months. The pause is probably seasonal and temporary, and there is no need for alarm. Great Britain's sun has not yet set as an industrial power. Throughout the storm and stress of the post-war years political and economic stability has been maintained, and if this country is no longer regarded as *the* workshop of the world it is still the most important workshop of the world, with its industry as a whole on a sound financial basis.

World conditions are becoming more normal, and our iron and steel industry need fear no competitors. It is well also to remember the almost illimitable resources of the Empire in non-ferrous ores. Empire production is increasing year by year. There are aluminium refining plants in Great Britain that are the last word in modernity, zinc installation plants in South Wales that are thoroughly up to date, and copper refineries that are unsurpassed anywhere. It was said in the first paragraph that the year 1914 was the end of an epoch. It is not foolishly optimistic to consider that twenty years after we are beginning a new epoch, and the qualities that made British industry pre-eminent before will restore it to its former eminence.

The Effect of Impurities on Solder

The physical appearance of the bar cast from a 50-50 tin-lead solder is discussed and a recent investigation referred to which shows that small amounts of common, known impurities have an influence on the appearance and structure.

THE quality and purity of 50–50 tin-lead solder is judged by the physical appearance of a cast bar. Many consider that a smooth, shiny bar is indicative of quality, and that the presence of metallic impurities is reflected in a generally rough or frosty-looking bar. One aim of the solder manufacturer is to produce a bar which is clean and smooth, and the occasional persistent roughness which sometimes prevails is always the source of much concern. This roughness is variously attributed to antimony, copper, nickel, arsenic and other impurities whose effects have never been experimentally demonstrated. A recent investigation by Barber,[1] however, which had for its object the determination of the effects of small amounts of common, known impurities on the physical appearance and the microstructure of 50–50 bar solder, throws much light on the subject.

In the report of this investigation, reference is made to the work of Bannister and Tabor[2] on the surface appearance of solders, much of whose work is repeated, but it is considered that the authors did not emphasise the practical significance of the influence of extremely small amounts of impurities such as concern the manufacturer of high-quality solders, and in view of the many contradictory opinions held on the subject it was thought advisable to investigate this question a little further.

In the best grades of commercial 50–50 bar there is always a faint, rough line extending along the contraction crack or portion which freezes last. In this investigation the total impurity content of the metal, which is the purest commercially obtainable, was approximately 0·03%, and in the resulting 50–50 bar, the faint "frost line" was practically negligible. Alloys of known impurity content were made by alloying such solder with known amounts of different elements, and a bar was made from each alloy. Each bar was then examined visually for frost, roughness, etc., and sections were submitted to metallurgical examination.

The importance of determining the ratio of the mould mass to the bar was appreciated and initial experiments showed that an extreme in either direction to permit very slow or very rapid cooling is to be avoided, the best results being obtained by adjusting the thermal capacity of the bar and mould to the point where hot solder will just run freely to the end of the mould before partial solidification begins. In this work the mass of the mould was about eight times that of the bar it produced.

It is stated that pure 50–50 solder is preferably poured at 525° to 575° F. At higher temperatures there is undue oxidation of the metal, and at lower temperatures the appearance of the bar is unsatisfactory. The contraction crack down the centre of the bar is practically free from frost, and the bar is smooth and shiny. When pure solder is prepared under these conditions, the microstructure at 50 magnifications appears exceedingly uniform, homogeneous, and free from dendrites. At higher magnifications one can detect the light eutectic and the dark mixture of lead and solid solution.

The microstructure of pure solder, like other metals, depends largely on the manner in which it is treated. If pure solder is poured into a mould at too low a temperature so that the solder does not flow freely to the end of the mould, the bar will be frosty and the microstructure at 50 magnifications will reveal many dendrites. If, on the other hand, the metal is poured into a hot mould and allowed to cool slowly, the microstructure will again reveal large dendrites of lead and solid solution and the beautifully laminated structure of the eutectic. Actual commercial 50–50 bar solder, however, is not produced under either of these extreme conditions.

Observations on appearance and microstructure confined to 50–50 bar solder, as actually produced in the solder industry, show that antimony, up to 2%, has no effect on the appearance or the microstructure of 50–50 alloys. Only at higher concentrations are there obtained the curious raised, round spots or "cooling spots," thought to be characteristic of antimony, which form as the alloy cools. The presence of these spots is not reflected in the microstructure of the alloy. On low-tin alloys such as 45–55, the addition of 0·5 to 1% antimony actually produces a bar as smooth and free of frost as pure 50–50. Microscopic investigation of antimonial solder reveals the characteristic square, unetched crystals of SbSn only when the antimony content reaches 3% or more. Bismuth up to 3% has no effect on the appearance or the microstructure of solder. Copper in amounts as high as 0·5% does not alter the appearance or the microstructure of solder. Only when the copper content approaches 1% does the solder bar become rough and frosty; in such an alloy the characteristic needles of Cu_3Sn are clearly distinguishable under the microscope. Silver at 0·05% produces no local frost line or cooling spots, but does produce a general or pronounced "velvety" appearance on the entire surface of the bar in contrast to the bright finish of pure 50–50 solder; the microstructure is unaltered. Nickel in amounts ranging from 0·03 to 0·25% gives rise to countless cooling spots, but no frost line. The microstructure of a 0·10% nickel alloy is identical with that of pure solder. When the nickel content reaches 0·25%, microscopic examination reveals long, unetched, needle-like or occasionally star-shaped portions which are quite similar in physical appearance to Cu_3Sn. Arsenic is similar to nickel, causing in amounts as low as 0·03% many cooling spots, but no frost, even at 0·25 %. Microscopic investigation of a 1% arsenic alloy reveals long, unetched needles, similar in all respects to the constituent observed in the cases of copper and nickel. This constituent persists down to 0·10% arsenic. When zinc is added to solder in amounts as low as 0·001% there results an extremely rough, frosty bar with the frost line covering almost its entire surface. Such a bar can be poured only at temperatures 150° to 200° F. higher than that required for pure solder. Although containing one part of zinc in 100,000 parts of solder, a bar of this character reveals at 50 magnifications a beautiful, crystalline network of fine dendritic needles distinctly different from the homogeneous appearance of pure bar solder. The dendrites, however, do not appear to be directly connected with zinc, and the influence of the latter appears to consist in altering the temperature at which the solder is mobile. Aluminium, like zinc, requires a high pouring temperature, and produces in amounts as low as 0·01% much roughness and a wide and prominent frost line. The microstructure of such a bar is a dendritic network similar to that of the zinc. Cadmium has the same effect as zinc or aluminium, causing at 0·01% an extremely rough, frosty bar and a highly dendritic microstructure. Aluminium and cadmium are, however, much less active than zinc in causing frost and altering the microstructure of solder.

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[1] C. L. Barber, *Ind. Eng. Chem.*, 26. Ind. Ed. No. 6, 1934, 685-7.
[2] Bannister & Tabor, *J. Inst. Metals*, 2, No. 2 (1909.)

Some Factors Influencing the Density and Soundness of Ferrous and Non-ferrous Castings

The influences controlling the density and soundness of castings are many and complex, but in the French Exchange paper by Mr. E. Longden, presented on behalf of the Institute of British Foundrymen, an exhaustive consideration was not attempted; instead he referred in general to the influence of elements in metal, the effect of dissolved and occluded gases in the metal on unsoundness and low density, the effect of gases generated and evolved from the mould materials, and the influence of mould materials on the constitution of cast metal alloys. In this article the paper is abridged and a few of the illustrations are reproduced.

UNSOUNDNESS covers a multitude of faults in cast metals, but here it is defined as the lack of compactness which appears as visible porosity and cavity. Porosity, of course, is a matter of degree, since all substances possess porosity. Density and soundness of castings can be influenced and controlled by the elements composing the alloy, melting practice, pouring temperature, mould materials, and moulding technique. Porosity and cavity which can be directly attributed to the ordinary metal composition can be readily dealt with in the light of modern metallurgical knowledge, but of equal or greater importance is the treatment of these alloy mixtures during melting and manufacture into castings of various shapes and section.

The density of an alloy can be determined theoretically by calculation from the specific gravity of the respective metals and metalloids composing the alloy, but such determinations can rarely be correct, since metal densities are so much influenced by gases, pouring temperatures, and speed of pouring, especially in alloys of the bronze series and aluminium. Again, the density of certain alloys may be greater or less than the mean of the metals and elements composing the alloy.

General porosity can be materially reduced by employing dense metals and control of pouring temperature. Metals and alloys of a short freezing range tend to produce denser metal than those of longer solidifying range, but whilst metals of short freezing range give greater freedom from general porosity, there is greater risk in such metal of actual cavity and blow-holes if due regard is not paid to the provision of adequate feeder heads and the condition of the mould materials.

The freezing range of an alloy is determined by the components or elements in the alloy which affect the latent heat of fusion, superheat above melting point, final pouring temperature, section or mass in a casting, and the state of the mould materials. Most metals undergo slight, and in certain cases considerable, volume changes at the point of solidification and at some stage after solidification.

Grey Cast Iron.

Grey cast iron, which is by far the most commonly employed of commercial metals, is of outstanding interest, and is subject to considerable volume changes in solidifying and cooling. It is a complex alloy of metals and metalloids, and is made up of 90% or more of iron compounded with carbon, silicon, phosphorus, manganese, sulphur, etc. Such compounds occupy in the metal considerable volumes. A pig iron containing 6½ to 7% of the metalloids holds by volume 36 to 38% of compounds formed as a result of their presence. All the elements have, therefore, positive reactions with iron and with each other.

The considerable volume changes in grey iron are mainly due to the swelling action of precipitated graphite on the dissociation of primary and secondary carbides from solution. The quantity and condition of the carbon is influenced, principally, by the presence of silicon, and to a lesser degree by the other elements contained in the metal, origin and mode of manufacturing the virgin metal, temperature of melting in the cupola, cooling or freezing rate as influenced by pouring speed and temperature, mass or section of metal in the casting and general condition of mould and mould materials.

The enormous expansion consequent on the precipitation of graphite from cementite or carbide neutralises very largely liquid shrinkage. The amount of expansion will depend on the analysis, original density of the metal, and the original condition of the carbides, and the effect of the subsequent cooling-range time and temperature. The size of the crystals will also vary with the speed of solidification.

It is obvious that the density and soundness of grey iron castings depends, primarily, on the amount and condition of the carbon. This aspect has been exhaustively probed and is very conclusive so far, but much work requires to be done on the effect of both dissolved gases held in solution or freed during freezing, and the influence of mould gases interacting with such occluded gases and the mechanical presence of same in the metal section.

The freezing range of a metal will influence the amount and also the condition of gases retained in solution with the metal and the quantity freed from solution. Gases when passing out of solution will cause an increase in the volume occupied by the metal unless completely freed from the molten metal. Carbon precipitation will tend to favour the release of gas from solution. Therefore, the chemical and physical reactions, as a result of carbon changes and gas release, probably provide the expansive and growth propensities of grey iron. The orthodox chemical analysis of metals may be misleading, and does not convey the whole story of metal. Analysis may indicate the amount of an element, but not its condition. For instance, graphite exists in cast iron in many forms, and is described variously as flaky, nodular, curly, and sooty, etc. The amount of carbon may be the same, but there is a wide difference between the strength and wear qualities, etc., of metal containing flake graphite and sooty graphite. Again, except experimentally, no account is given of the amount and condition of absorbed or dissolved gases.

There is evidence that gas-free iron resists growth more effectively than metal with normal gas content; but the growth and expansive forces in grey iron will be created by the deposition of graphite, deposits of other impurities as films around the crystal grains, the building-up of the crystal structure itself, and the pressure of dissolved gases.

Dissolved Gases in Steel.

The effect of dissolved gases on a comparatively purer iron-steel is very remarkable. In producing steel ingots, for instance, generally there are three classes of metal obtained by controlling the gas content. The steels made are stated to be fully or completely piped, balanced, and ebullient. The fully piped steel solidifies in the mould with little release of gas. It is very free from blow-holes, but contains a large pipe or cavity, or series of pipes in the upper central portion of the ingot. To reduce this cavity hot feeder heads are provided.

The midway or balanced type of steel is produced by pouring the metal into the mould in such a way that much gas is not released until the temperature of the metal in the mould has been reduced and sets early. The ebullient steel, or weld steel, as it is termed, ebullates considerably

during freezing. Freezing is accelerated by closing down on the top of the mould a heavy steel plate, which prevents the release of gas. This class of steel shows little apparent piping.

Each class of steel is controlled by pouring speeds and the employment of added elements which influence the solubility of gases in the metal. The most commonly used elements are silicon, titanium, and aluminium. There are also processes for subjecting molten steel and other metals to mechanical pressure during freezing. Huge volumes of gas are given off during the pressure stage. Steel castings, however, undergo little volume change on solidification to compensate for liquid shrinkage, as in the case of cast iron, when carbon is precipitated from solution; consequently, liquid shrinkage is considerable and heavy feeder heads are employed.

Malleable Cast Iron.

Of the ferrous metals, white cast iron for malleable castings follows close to steel in the order of liquid shrinkage, although the solidifying metal undergoes a certain amount of volume change during the freezing stages, due to the presence in the iron of greater quantities of impurities, combined carbon, and traces of graphite, liquid shrinkage compels the use of heavy feeder heads, but not so heavy as for steel. In the hard state, before malleabilising, the castings contract very closely to that of steel, but during malleabilising—annealing process—the castings grow in volume. This growth in the solid state is due to the volume change consequent on dissociation of cementite into temper graphite.

Liquid Shrinkage and Gas in Ordinary Grey Iron.

The effect of gases on steel is very obvious, and to a smaller extent in malleable iron. The influence is not so clear in the case of grey iron containing large quantities of impurities. When graphite is precipitated, considerable pressure is set up within the metal, much of which pressure and growth expends itself on the fluid interior as the metal cools layer by layer, but, also, much of this swelling action is exerted outward, and distention of the solidifying envelope takes place at several temperature stages. Sand moulds respond to this external pressure, and at some critical stage, depending on the composition and cooling rate, the casting is larger than the containing sand mould. Experience has shown, however, that the stronger and more resistant the mould, along with acceleration of the heat abstraction by the thermal conductivity of the mould materials and reduction of mould gases, the sounder and more dense the resultant casting. This hypothesis is especially applicable to grey cast iron, but also in a smaller degree to any cast metals. The author has demonstrated that castings are most unsound, and possess the lowest density when made in green sand moulds, sounder and more dense when made in dry sand moulds, still sounder and more dense when the metal, is cast into loam moulds, and when poured into a dried ganister or metal mould liquid shrinkage is almost completely absent.

The author emphasises the powerful influence of the mould materials on the soundness of cast iron, and supports his opinions by a large number of illustrations representing fractures of test castings. One of these is reproduced in Fig. 1, which shows three fractures of gear blanks used as a test for the effect of mould conditions on a hematite iron. The section is 2¼ in. × 3 in., and the diameter of the blank 13 in. The composition of the metal which was cast at a temperature of 1,375° C., is given in the following table :—

	C.C.	G.C.	Si.	Mn.	P.	S.
Section A	0·30	3·62	2·4	0·9	0·04	0·04
,, B	0·40	3·52	2·4	0·9	0·04	0·04
,, C	0·23	3·69	2·4	0·9	0·04	0·04

The left-hand section A shows the result when poured into a green sand mould through an ingate area ½ sq. in. and a feeder head of approximately 8 sq. in. General open grain is evident. The section C, on the right-hand side, was spun-cast in dry sand in a "Craven" centrifugal casting machine. The middle section B was poured into a stationary green sand mould, but with a ring densener around the whole of the outside of the rim. The same ingate area was used throughout, but in the latter case only a relief riser was provided. The relative densities of the metal in these sections proved to be 6·91, 7·045, and 6·92 for A, B, and C respectively, while the Brinell hardness values were 90, 137, and 95 respectively. It will thus be seen that the casting produced in a mould with a ring densener is of greater density and hardness than the blank spun-cast in sand. This test is shown to illustrate the enormous expansive and pressure effect on the metal structure when shell expansion is resisted and the speed of freezing accelerated.

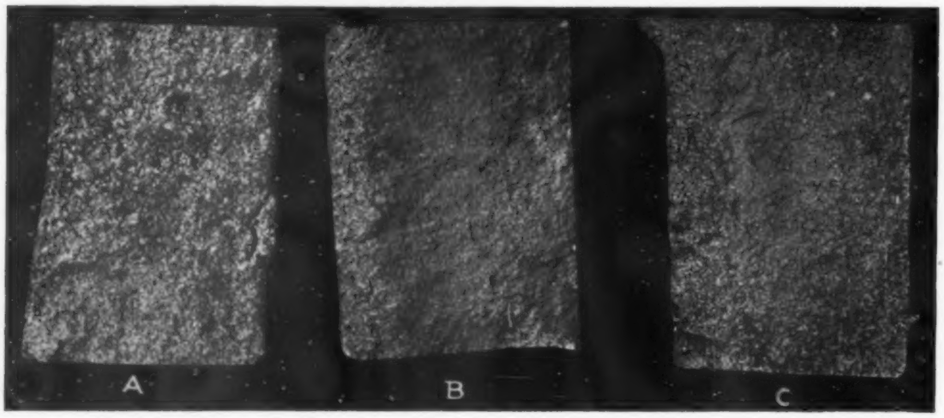


Fig. 1.—Three fractures of gear blanks showing the powerful influence of mould materials on the soundness of cast iron.

It has been calculated that when spinning gear blanks from 12 in. to 24 in. diameter at 700 to 900 r.p.m., a pressure is set up equal to from 60 to 100 times that of gravitation. It is therefore evident that the pressure set up in the densened casting is much greater than that which is spun in a sand mould. This is true only of grey cast iron.

Several sections of test-bars are illustrated as in Fig. 2. All the bars were poured from metal of the following composition: Total carbon, 3·2%; silicon, 0·9%; phosphorus, 0·5%; manganese, 0·7%; and sulphur, 0·11%. Sections D, E, and F are 1 in. sq. by 14 in. test-bars, while G represents a section of a test-bar 1¼ in. sq. by 14 in. The blow-holes shown in section D are caused by entrained air and slag passing into the mould with the metal. Section F resulted when the metal was poured into a warm dry sand mould, and those at E and G from the use of a cold green sand mould. This test illustrates the effect of mould conditions. The warm mould, with the 1 in. sq. section, yields a dense, sound grey iron, the 1¼ in. sq. section, cast in cold mould, is not quite grey throughout, and has a central pipe or blow-hole

surrounded by mottled white structure. The 1 in. section cast in a cold green sand mould is blown quite across the section and heavily gassed. In the latter case the unsoundness is probably due to mould and occluding gas, in addition to the heavy liquid shrinkage consequent on retention of carbon in solution. Another illustration, shown in Fig. 3, shows a $2\frac{1}{2}$ in. diameter $\times$ 14 in. cast-iron stick section poured horizontally. The moulds are cast with a special crucible cast metal, which is well melted and of correct composition. It is evident from this section that the mould gas found an easier passage through exposed vent-holes on the mould face and into the metal than by the more difficult route via the bottom of the mould-box.

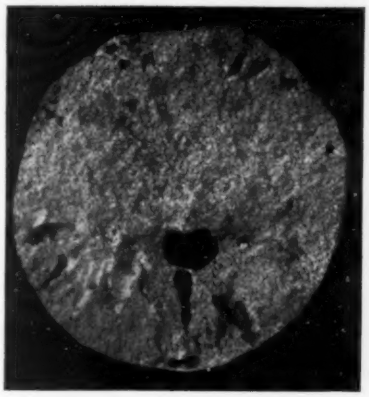


Fig. 3.—A cast-iron stick section showing the effect of exposed vent-holes on the mould face.

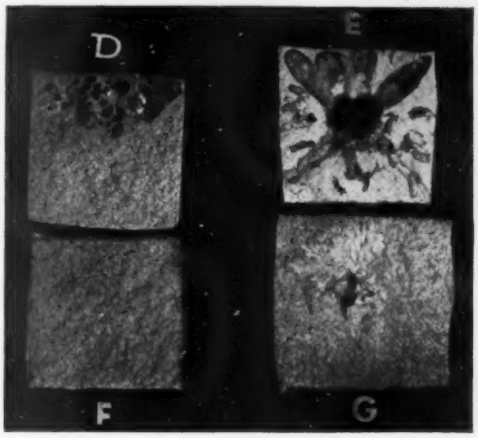


Fig. 2.—Several sections of test-bars showing the influence of mould conditions.

Non-ferrous Castings.

Most non-ferrous metals have a high liquid shrinkage. As with steel, this high liquid shrinkage imparts tremendous cohesive force and pressure on the crystal grains, conferring a high mechanical strength or hardness to a metal. Density and soundness in such metal as bronze is most markedly influenced by the freezing range as determined principally by the pouring temperature, condition of the mould and section. Consequently, close study is made into correct pouring temperature control by pyrometer, correlating the known cooling range of the particular alloy with the mass section of the casting being produced. Consideration must also be given to the sensible disposition of runner and riser-gate feeder heads. If the combination is well judged, the head metal will be seen to sink rapidly within a few seconds after pouring.

The use of chill or denseners in non-ferrous alloys does not function so effectively as with grey cast iron, which holds such large quantities of graphite carbon, etc., but the judicious application of denseners on heavy sections, or hot locations of a casting, will facilitate a rapid passage of such sections from liquid to solid, having drawn its quota of shrinkage metal from the later solidifying areas of the casting, which will have more immediate contact with suitably located feeder heads.

Gases absorbed during the melting of non-ferrous alloys, and the tendency for such gases to occlude on cooling, provides serious study if the maximum success is desired. The amount of gas absorbed and occluded will depend on the melting practice, pouring temperature, and nature of alloy. A very slow cooling rate will favour the liberation of the maximum amount of gas, but it will create, in general, large crystals. An intermediate cooling rate will be conducive to the metal occluding gas which cannot liberate itself from the solidifying alloy, and may result in general porosity, cavity, and blow-holes. In aluminium this stage is characterised by the appearance of numerous pinholes throughout the metal sections. A rapid freezing rate gives little time for gases to become liberated. With gas so held in solution, very sound, dense castings are produced. Aluminium has great propensities to absorb gases, and is particularly sensitive to gas inclusion, which, if not controlled, shows up as fine pinholes, speckled metal, and with general low density.

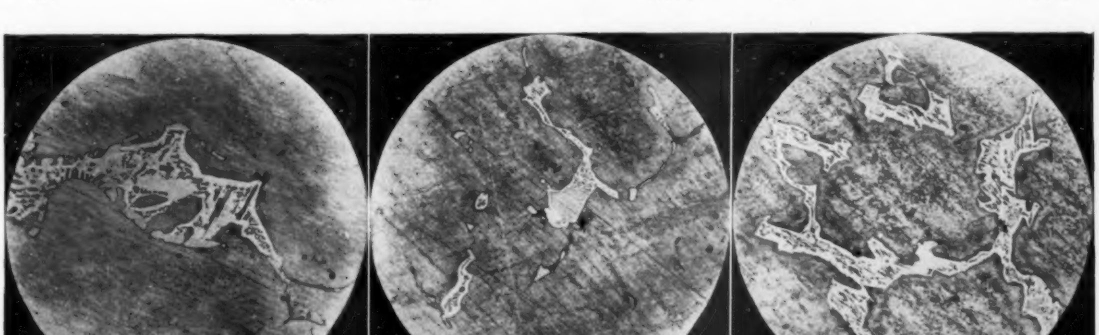
The excellent research work by Archbutt and Prytherch on the practical elimination of the baneful effect of uncontrolled gases in aluminium is well known. A process originated by Archbutt and termed the pre-solidification process, consists of allowing the metal, after first melting, to solidify in the furnace or crucible, and to again melt the metal and bring up to the required temperature sharply and pour into the mould. This process allows the free liberation of gases in such a light alloy as aluminium. When melting copper or aluminium, the formation of oxides should be prevented as much as possible, since oxides once formed are difficult to eliminate from the melt due to the affinity of oxygen for such metals and the high temperature melting point of the oxides.

Centrifugally Produced Castings.

The almost complete control which can be exercised on the constitution of the metal, especially non-ferrous

Fig. 4—The beneficial effect of centrifugal action and force on the structure of metal is shown by an examination of these illustrations.

A2 $\times 500$ A5 $\times 500$ A9 $\times 500$



alloys of the bronze series, is well amplified in the production of castings by the centrifugal process. The beneficial effect of centrifugal action and force on the structure of metal is well illustrated by an examination of the photomicrographs A2, A5, and A9. It will be noted that the alpha-delta eutectoid (hard constituent) is more evenly distributed in the matrix of alpha (softer constituent) copper-tin solid solution in the case of A9, the spun-cast metal, than in A2 or A5, the sand-cast metal and ring-chilled respectively. Tensile strength of the spun material is from 20 to 30% greater than sand cast. The photomicrograph A5 shows a poor and low distribution of the necessary hard constituent. In the sand cast, A2, there are very obvious gas holes and gas fissures, and, to a smaller extent, also in A5.

Size Preparation of Iron Ores

Tests have shown that more thorough sizing of iron ores offers one of the most promising fields for improving blast-furnace practice; this involves sintering fine or concentrates and proper size reduction of hard, coarse ores, according to a recent investigation.

THE efficiency of ore reduction in the blast-furnace and fuel requirements depend upon the degree of uniformity with which reducing gases can be distributed through the stock column and upon the permeability of individual pieces of ore and sinter. If the ore is fine, the major problem in reduction is to get the ascending gas stream to the surface of the ore. Hard, dense ores of low permeability, mined in coarse sizes, tend to improve the permeability of the bed, but, unless they are crushed to the proper size, they reach the hearth unreduced. Surveys have shown conclusively that the gas distribution in the upper three fourths of the furnace is far from ideal. Furnace lines, top design, and methods of charging are important, but more thorough size preparation of the ore is necessary to eliminate size segregation at the stock line, which inevitably leads to non-uniformities in gas distribution. Because of the quantity of sinter now produced close study of the characteristics which determine its behaviour in smelting is warranted, and a recent report[1] by Mr. T. L. Joseph is of considerable interest. As the use of concentrates increases agglomeration will become more of a necessity. Improvements in the physical character of the ore burden are particularly important to plants using coke of poor physical quality. In addition to aiding reduction, improved physical properties of the ore burden will permit the use of higher blast heats, which is equally important.

Previous reduction tests on minus 0·742- plus 0·525-in. pieces of commercial sinters revealed large differences in porosity and reducibility. The results have been published in a former report.[2] Although the physical properties of the sinter, particularly porosity, were found to be of major importance in determining the rate of deoxidisation, it appeared that certain chemical properties of the sinter appreciably retarded the reduction of sinters high in silica. This was attributed to the presence of fayalite, which has been identified by Schwartz and by Luyken and Kraeber[3] as an important constituent of sinter. Although furnace operators and metallurgists have assumed that iron silicate is more difficult to reduce than hematite or magnetite, definite data on the reduction characteristics of this material were not available. Tests were undertaken, therefore, to develop a method for determining the amount of iron silicate present in sinters, so that its effect upon reduction could be observed.

Summarising the results of the investigation, the author considers that more thorough size preparation of iron ores, which involves sintering fine ores and concentrates, and proper size reduction of hard, coarse ores, offers one of the most promising fields for improving blast-furnace practice. Reduction studies indicate that physical properties of sinter are more important than chemical properties in controlling rates of reduction of such sizes as are used in the blast furnace. A method was developed for determining the amount of iron silicate in sinter. This constituent of sinter increases sharply from 8 to 10% of silica, and above this range enough is likely to be present to retard reduction appreciably. If the silica exceeds 10%, significant amounts of iron will exist as ferrous silicate, which in all probability reaches the hearth unreduced. This mineral is slowly reduced, and forms a protecting coating around grains of magnetite. The silica content of the sintering mixture should be considered in sintering practice. Strong, dense, blocky sinters made from siliceous material are reduced slowly because of the combined effects of the physical and chemical properties.

The time required to reduce coarse particles of ore increases directly with the diameter of the pieces. With porous sinters the solid continuous sections may be as thick in ¾-in. as in 1·5-in. pieces. Large pieces of hard, dense sinters appear to be objectionable, particularly if produced from siliceous material. The permeability of dense iron ores, mined in coarse sizes, appears to be a promising criterion for determining the size to which the ore should be crushed. The chemical properties of the iron minerals are relatively unimportant. Permeability measurements on a number of ores from various districts vary widely. The significance of large differences in permeability will not be known until results of reduction tests are available. Such tests are now in progress.

[1] U.S. Bureau of Mines Report of Investigations 3240.

[2] Joseph, T. L., Barrett, E. P., and Wood, C. E., "Composition and Deoxidation of Iron Oxide Sinters: Blast Furnace and Steel Plant," vol. 21, March, April, May, June, 1933, pp. 147-150, 207-210, 260-263, 321, 323, and 336.

[3] Schwartz, G. M., "Iron Ore Sinter: Am. Inst. Min. and Met. Eng." Tech. Pub. 227, September, 1929, p. 30. Luyken, Walter, and Kraeber, Ludwig," "Induced Draft Sintering of Iron Ores: Mitteilungen, Kaiser-Wilhelm-Institut fur Eisenforschung," rept. 192, vol. 13. 1931, p. 253.

The essential characteristic of an alloy for the manufacture of heating elements for furnaces, cookers and heating apparatus is resistance to progressive oxidation. With an 80/20 nickel-chromium alloy this is exceptionally high, due to the fact that the alloy becomes covered with a thin coating of oxide which has the unique property of resisting the penetration of oxygen, thus preventing further oxidation. This oxide coating is firmly adherent and shows no tendency to flake or scale off when the resistor contracts on cooling. A further advantage of the 80/20 nickel-chromium alloy is its good mechanical strength, especially at high temperatures, this property being particularly important in large heat-treatment furnaces handling heavy loads where the resistors are necessarily of large section.

The adoption of dredging as a method of excavating ore in the tin mining areas of Malaya has resulted in a considerable reduction in the cost of developing the ore. The dredgers are mounted on floating craft and work alongside river banks or over land areas purposely flooded. One of the largest of these dredgers is that recently designed and constructed by F. W. Payne and Sons, for Malayan Tin Dredging, Ltd., with a theoretical digging capacity of 711 cubic yards per hour. The buckets are fitted with nickel-chromium-molybdenum steel pins, and the sheave pins of the hoisting gear are of nickel-chromium steel.

New-type Installation Equipment Built of Arc-welded Aluminium

By A. F. Davis.

Rapid progress is being made in the fabrication of aluminium, in order that it can be applied successfully in an ever-increasing field, and in this article brief information is given of the construction of an aluminium distillation equipment which is probably the first of its kind to be fabricated by means of arc welding.

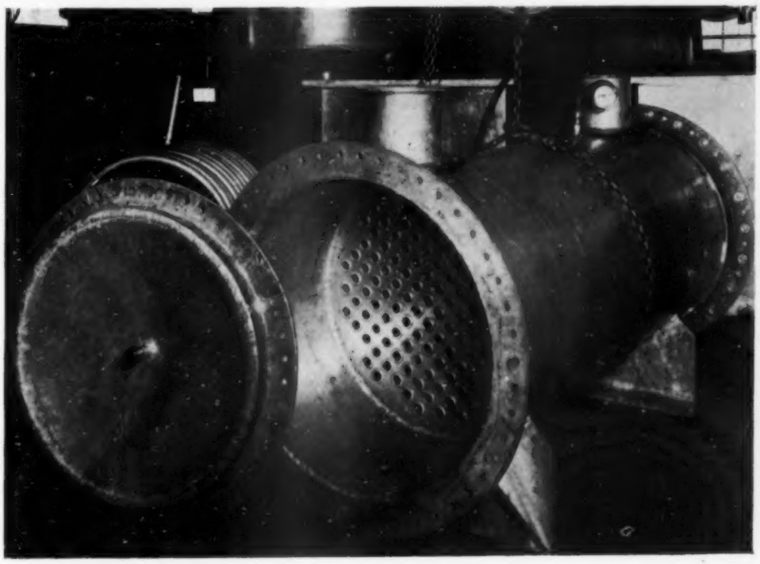


Fig. 2.—One of two condensers of $\frac{3}{8}$-in. aluminium. The condensers are 8 ft. long and 3 ft. in diameter, and operate under 100 lb. pressure.

CONSTRUCTION of arc-welded aluminium distillation equipment for a new chemical process has been completed by The Thornton Company, Cleveland, Ohio. The equipment is believed to be the first of the kind ever built, and is one of the most involved welded-aluminium projects yet reported. As shown in Fig. 1, the process requires a still connecting with two condensers below which are two drip tanks and two receiving tanks.

The still, which may be seen to the left in the photograph, is 7 ft. 4 in. high and 3 ft. 6 in. in diameter. It is built of $\frac{5}{8}$-in. aluminium welded with one longitudinal seam, the edges of the plate being vee'd out preparatory to welding. The bottom of the still is a dished plate. The top is bolted on by means of 4 in. by $4\frac{3}{4}$ in. angles, which are lap-welded to the body of the still and to the top. The forming of these heavy angles was a difficult operation. Inside the still is a 3-in.-diameter coil of extra strong aluminium pipe, 15 coils high. The still operates under a 29-in. vacuum.

The two condensers are exceptionally interesting. They are 8 ft. long and 3 ft. in diameter. The shells and heads are of $\frac{3}{8}$ in. plate, and the bulkheads of $\frac{1}{2}$ in. One hundred and forty tubes are used in each condenser. No difficulties were experienced in the welding of these condensers, despite the heavy plate used. Welds were tested under 100 lb. pressure, and no flaws were found in any of the welds. The condensers operate at 75 lb. pressure. Supports for the condensers were also welded of heavy plate, as shown in Fig. 2.

Eight-inch piping connects the condensers and the still. This piping was fabricated complete by arc welding from aluminium sheets. More than $50 was saved on this piping alone over the cost of cast fittings.

The two rectangular and two cylinder receiving tanks below the condensers were also arc welded in their entirety, including the fittings. All welding was done by the shielded arc process, using " Aluminweld " electrodes and arc welding generators manufactured by the Lincoln Electric Company, Cleveland, Ohio. The electrode used was selected on the basis of maximum penetration, density and ease of handling. Sheets used were 3S aluminium throughout.

Many unusual problems arose since this distillation plant is the first of its kind to be built, and there were no precedents to follow. Arc-welded construction was decided upon due to its simplicity, speed and efficient distribution of metal. According to the manufacturer, any other method of construction would necessitate the use of expensive castings, which would also increase the weight of the equipment, and would require much longer time to complete.

Fig. 1.—Distillation equipment for a chemical plant built entirely of arc-welded aluminium.

Heat Transference in Non-ferrous Metals in Reheating Furnaces*

By G. Wagener.

This article deals with the results of laboratory and works experiments on the estimation of heat transfer coefficients of aluminium, copper and brass. Owing to the lower absorption of radiation by the bright surfaces of the non-ferrous metals, these coefficients are much lower than that of iron.

In recent years reheating furnaces for iron have been the subject of numerous investigations, and the various factors of importance for calculations and for the running of the furnace have to a large extent been removed from the realms of uncertainty and empiricism.

With non-ferrous metals the position is very different, not even the most necessary bases for approximate calculation being available. It is generally supposed that the higher conductivity of these metals, as compared with iron, will shorten the time of heating, more rapid conduction of the heat to the interior allowing increased uptake by the surface. Both form part of the full process of reheating. The transfer of heat at the surface due to contact (convection) and radiation can be represented by the usual equations :—

$$Q = \alpha F z(t_0 - t_2) \text{ Cals.}$$

$$dQ = \alpha F dz dt_a \quad \ldots \quad (1)$$

and

$$Q = \lambda_s F_1 z(t_2 - t_3) \text{ Cals.}$$

$$dQ = -\lambda F_1 dz \frac{dt_1}{ds} \quad \ldots \quad (2)$$

where F = surfcae of material, in sq. metres, taking part in uptake of heat ;
z = time in hours ;
t_0 = furnace temperature,
t_2 = temperature of surface of metal ;
t_1 = temperature of centre of metal ;
λ = thermal conductivity, in Cals. per metre per hour per degree ;
s and ds = elongation in direction of flow of heat, in metres ;
α = heat transfer coefficient in Cals. per sq-metre per hour per degree.

As equation 2 shows, the flow of heat to the interior of the metal depends on both conductivity and temperature gradient. The latter must not be such that excessive strains occur owing to the difference in temperature between the exterior and interior of the metal, or tearing of the metal may occur (a steel billet, inadvertently placed whilst cold in the hottest part of the furnace, showed gaping cracks in the surface on being drawn). Under normal conditions the heat transference of " the narrowest cross-section," and not the conductivity, governs the heating of the charge, and even with large cross-sections and the highest heat transfer coefficients as yet attained, the temperature gradient must lie within limits imposed by the material.

The reheating process is mainly influenced by the heat transfer coefficient, and the only consequence of a higher conductivity is that, heat transmission being the same, a smaller temperature gradient is necessary to make the passage of heat inwards possible. The material influences the transfer of heat, not through its physical constants, but through the nature of its surface. By assuming a definite heat transfer coefficient one may calculate, with the aid of the diagrams put forward by Grober (1), the heating period and the difference in temperature between the exterior and interior of geometrically-simple bodies ; thus, despite its lower conductivity, aluminium is found to require a shorter heating time than copper, where the conditions are the same. The calculation covers the influence of the physical constants, but is valueless when the heat transfer coefficients are unknown, as has so far been the case with non-ferrous metals.

The work described herein is a contribution to the filling of these gaps. It was carried out in the experimental

TABLE II.—LABORATORY EXPERIMENTS—SERIES 1 TO 4.

		Series 1.				Series 2					
Experiment No.		1 (Al)	2 (Al)	3 (Al).	4 (Al).	5 (Cu).	6 (Cu).	7 (Fe).	8 (Cu).	9 (Al).	10 (Fe).
Furnace	—	Electric.				Electric.			Mindoga.		
Dimensions of test-piece	Mm	120 × 40 × 40	180 × 60 × 60	240 × 80 × 80	300 × 100 × 100	180 × 60 × 60	120 × 40 × 40	120 × 40 × 40	180 × 60 × 60	180 × 60 × 60	180 × 60 × 60
Surface	M2	0·0224	0·0504	0·0896	0·140	0·0504	0·0224	0·0224	0·0504	0·0504	0·0504
Weight	Kilos.	0·52	1·73	4·12	8·1	5·74	1·662	1·4	5·74	1·73	5·1
Furnace temperature, t_0	°C.	509	492	486	499	499	508	498	672	660	606
Initial temperature, t_1	,,	18	16	22	15	17	18	18	18	19	15
Final temperature, t_2	,,	450	452	460	447	454	455	451	457	463	449
Increase in temperature	,,	432	436	438	432	437	437	433	439	444	434
Heat absorbed	Cals.	53·1	178	426	825	249·5	72·4	80	250	181	292
Time of heating, z	Mins.	22	45	65	87	51	32	22	17	15	14
Spec. heat load, q	$\frac{\text{Cals.}}{m_2, h}$	5,480	4,710	4,400	4,060	5,820	6,060	9,730	17,550	14,400	24,900
Mean surface temperature, t_m	° C	327	322	318	342	290	304	314	312	350	298
Mean temperature difference	,,	182	170	168	157	206	204	184	360	310	308
$(t_m - t_1) : (t_0 - t_1)$	—	0·63	0·64	0·64	0·68	0·57	0·583	0·62	0·53	0·52	0·48
$(t_m - t_1) : (t_2 - t_1)$	—	0·72	0·70	0·68	0·76	0·63	0·66	0·68	0·67	0·75	0·65
Coefficient of heat transmission	$\frac{\text{Cals}}{m_2, h_0}$	30·1	27·7	26·2	25·9	28·2	29·7	52·8	48·7	46·4	80·8

* Nickel-plated.

* Translated by I. Boodson from *Der Warmeubergang an Nichteisen Metallen in Warmeofen*, Zeitschrift f. Metallkunde, vol. 24, No. 2, p. 35, with the author's permission. (Abridged.)

1 *Z. VDI*, vol. 69 (1925), p. 705 ; and *Warmeubertragung*, J. Springer, Berlin, 1926.

rolling mill of the Technische Hochschule, Breslau, and supplemented by works experiments with the co-operation of the Hirsch Kupfer-und Messingwerke A.G., Finow. The results include some obtained by their Dipl. Ing. Hoffmann in the same sphere a short time previously.

The laboratory experiments provided data for the determination of the heat transfer coefficients of copper

TABLE I.
PHYSICAL CONSTANTS OF MATERIAL USED.

Material.	Aluminium.	Copper.	Iron.	Brass.
Mean specific heat (0 to 600° C.) Cals./kilo/deg.	0·236	0·0994	0·132	0·092
Specific gravity, kilo/cub. m.	2,700	8,500	7,750	8,500
Thermal conductivity, Cals./metre/hour/deg.	226	335	40	85

and aluminium in different furnaces and at different temperatures, and made possible a comparison of these with that of iron under the same conditions. The works experiments served to verify the laboratory values under actual working conditions.

When the furnace had attained constancy at the required temperature, the material was put in: the temperatures of the furnace, the interior of the test-piece and its surface were measured in relation to time, standardised nickel—nichrome and iron—constantan thermo-couples being used.

Series 3.			Series 4.			
11 (Al).	12 (Fe).*	13 (Cu).*	14 (Cu).	15 (Cu).	16 (C).	17 (Cu).
Mindoga.			Electric.			
180 × 60 × 60	180 × 60 × 60	180 × 60 × 60	180 × 60 × 60	180 × 60 × 60	180 × 60 × 60	120 × 40 × 40
0·0504	0·0504	0·0504	0·0504	0·0504	0·0504	0·0224
1·73	5·08	5·76	5·744	5·744	5·744	1·662
583	621	626	270	405	670	825
14	14	15	15	15	15	15
452	450	451	215	355	620	775
438	436	436	200	340	605	760
179	294	250	114	194	344	125·5
16	29	28	62	72	36	21
13,300	12,020	10,064	2,200	3,210	11,400	16,000
285	318	300	158	263	424	540
298	303	326	112	142	246	285
0·48	0·50	0·47	0·56	0·64	0·62	0·65
0·62	0·70	0·65	0·71	0·73	0·68	0·69
44·6	39·7	32·7	18·0	22·6	46·4	56·2

To get the temperature of the surface, the hot junction was tightly held against it by small brass screws, whilst to get that of the interior the junction was placed in a borehole packed with copper turnings. The constants used in the culculations are given in Table I. and Fig. 1, and the experimental results in Table II. series 1 to 4.

The first step in the evaluation was to calculate, from the weight, specific heat and increase in temperature of the material, the amount of heat transferred, and from the latter the heat in Cals. per hour. This value divided by the surface of the material gave the "specific heat load" in Cals. per sq. metre per hour, a value first used by Tafel and Grünn (2) for iron in connection with the specific steam load of boilers. The mean surface temperature during the experiment was then obtained planimetrically from the temperature curve. Finally, the heat transfer coefficient was obtained in Cals. per sq. metre per hour per degree by dividing the heat load by the difference between the furnace temperature and the mean surface temperature.

The works experiments were carried out and evaluated in a similar manner. When the furnace was charged, thermo-couples, connected through a switch with a precision millivoltmeter, were placed on the top, and between the ingots, of the middle pack. They consisted of 1 mm. nickel-nichrome wires insulated by asbestos wrapping. The furnace temperature was measured by means of standardised works instruments.

Experimental Results.

Four samples of aluminium (Table II. series 1 and Fig. 2) were investigated in the electric muffle at 500° C. The experiments were stopped before the surface of the metal

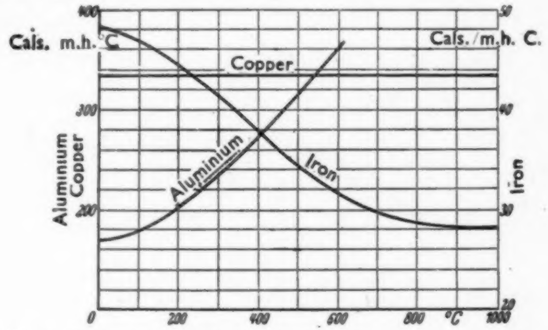


Fig. 1—Thermal conductivity of aluminium, copper, and iron (reproduced from Prioform-Handbuch, 1930).

attained the temperature of the furnace, as the time could thus be more accurately determined: at complete equality the slope of the two temperature curves makes the actual point of intersection very uncertain. Control experiments show that heat transfer coefficients thus determined can be used in estimating the total time of heating. The coefficients lay between 25 and 30 Cals. per sq. metre per hour per degree, the heat load between 4,000 and 5,500 Cals. per sq. metre per hour, the higher values being given by the smaller test-pieces; increasing the weight of the ingot further, decreased the value but slightly.

The heat was taken up fairly evenly all over in this furnace, which was wound with resistance wire over its whole length, the total and the effective surfaces thus being the same. At high temperatures radiation constitutes the major portion of the heat transferred, and the effective surface is that which, so to say, "sees" the radiating furnace walls or gases. When the experimental results are used, this surface must be carefully estimated.

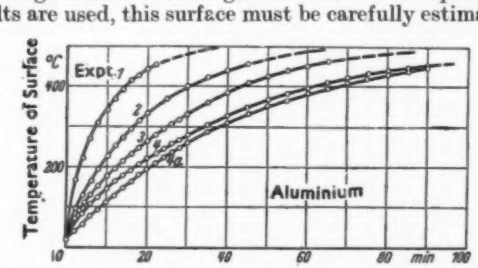


Fig. 2—Aluminium: furnace temperature, 500° C. 4A = temperature of interior in Experiment 4.

In Series 2 (Table II., and Figs. 3 to 5) investigations were carried out on copper and iron in the electric furnace at 500° C., and on these and aluminium in the Mindoga (gas-fired) furnace at 600° C. The heat transfer coefficients for copper and aluminium are approximately the same when the conditions are the same, but are considerably below those for iron. As the surface of the nonferrous metals (drawn, rectangular) was bright, whilst that of the iron (rolled, square) was dull, the difference in coefficients is obviously due to the greater reflection and reduced absorption by the bright surfaces. This is supported by the results obtained in Series 3 (Table II. and Fig. 6), where the conditions were the same as in Series 2, except that the copper and iron were nickel

2 Wärmeleistung von Stossöfen, *Stahl und Eisen*, Vol. 46 (1926), p. 1750.

plated. The heat transfer coefficient of aluminium remained approximately the same, those of copper and iron were considerably reduced, of the latter by about 50%. The somewhat higher value of the nickel-plated iron, as compared with the copper is due to the rougher surface of the iron used. Hence, at the same furnace temperature,

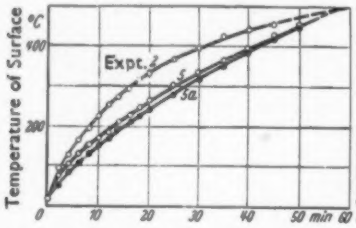


Fig. 3—*Aluminium* (2), *copper* (5); *furnace temperature,* 500°C. 5A = *temperature of interior in Experiment* 5.

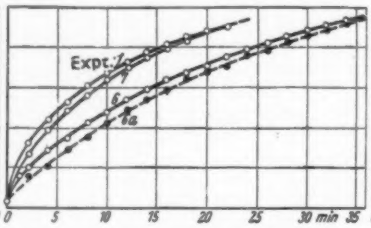


Fig. 4—*Aluminium* (1), *copper* (6), *iron* (7); *furnace temperature,* 500°C. 6A = *temperature of interior in Experiment* 6.

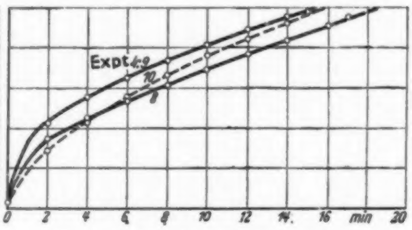


Fig. 5—*Aluminium* (9), *copper* (8), *iron* (10); *furnace temperature,* 500°C.

the heat transfer coefficient of a non-ferrous metal possessing its original brightness, or at any rate not strongly oxidised, will always be lower than that of iron with its normal casting or rolling skin.

Higher values were obtained in the Mindoga, than in the electric, furnace; the furnace temperature was, however, higher, proper control being difficult below 600° C. Experiments (Series 4, Table II., and Fig. 7) carried out at different temperatures in the electric furnace showed that the two types of furnace gave approximately the same coefficients, but that, as would be expected, there was a marked dependence on the furnace temperature. The values obtained in this series and those for copper and aluminium from series 1 to 3 are reproduced graphically in Fig. 8. The increasing influence of radiation at higher temperatures is very noticeable. This influence can be represented algebraically. Thus,

$$\text{Total heat } Q = Q_{\text{radiation}} + Q_{\text{conduction}} \quad \ldots \ldots \quad \text{Cals/hr} \quad (3)$$

$$\alpha = \alpha_R + \alpha_C \quad \ldots \ldots \ldots \ldots \quad (4)$$

$$Q_R = C\,F\left[\left(\frac{T_0}{100}\right)^4 - \left(\frac{T_m}{100}\right)^4\right] \quad \ldots \ldots \quad (5)$$

$$Q_C = \alpha_C\,F(T_0 - T_m) \quad \ldots \ldots \ldots \ldots \ldots \quad (6)$$

Taking the conditions in Fig. 9 with constant or mean temperature t_0 and parabolic rise of surface temperature in accordance with the curves, we have for equality of temperature

$$t_m = 0{\cdot}7\ t_0 \text{ approx.} \quad \ldots \ldots \ldots \ldots \ldots \quad (7)$$

For absolute temperatures in the range under consideration

$$T_m = 0{\cdot}8\,T_0 \text{ approx.}$$

(which is correct at 547° C.), so that equation (5) becomes

$$Q_R = C\,F\left[\left(\frac{T_0}{100}\right)^4 - \left(\frac{0{\cdot}8T_0}{100}\right)^4\right]$$

$$= C\,F\left(\frac{T_0}{100}\right)^4 (1 - 0{\cdot}8^4)$$

$$= C\,F\ 0{\cdot}59\left(\frac{T_0}{100}\right)^4 \quad \ldots \ldots \ldots \ldots \quad (8)$$

Also,

$$\alpha R = \frac{Q_R}{F\,(T_0 = T_m)}$$

$$= \frac{Q_R}{F\,0{\cdot}2\ T_0}$$

$$= C\,\frac{0{\cdot}59}{0{\cdot}2}\ \frac{1}{100}\left(\frac{T_0}{100}\right)^3$$

or

$$\alpha R = C\,0{\cdot}03\left(\frac{T_0}{100}\right)^3 \quad \text{approx.} \quad \ldots \ldots \quad (9)$$

If the heat transfer coefficient for convection, α_C, be taken as 10 Cals. per sq. metre per hour per degree (increased temperature and livelier circulation of the gases may raise it to 20) the total coefficient becomes

$$\alpha = C\,0{\cdot}03\left(\frac{T^0}{100}\right)^3 + 10 \text{ Cals. per sq. metre per hour per degree} \quad \ldots \quad (10)$$

Very good agreement with the experimental values is obtained if the radiation constant

$$C = \cfrac{1}{\cfrac{1}{C_1} + \cfrac{F_1}{F_2}\left(\cfrac{1}{C_2} - \cfrac{1}{C_0}\right)}$$

be given the value 1·27, corresponding to the radiation coefficient of copper in the condition investigated, if C_2 be taken as approximately equal to C_0 (= 4·96), or if the ratio of the radiated to the radiating surface be very small.

A similar equation can be obtained for the heat transfer coefficient of iron; in both cases the relation is to be regarded only as a practically useful summary* based on experimental results, with no claim to final validity, though supported by the above theoretical derivation.

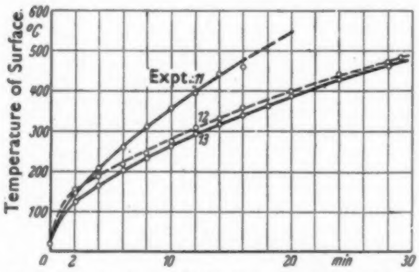


Fig. 6—*Aluminium* (11), *iron, nickel-plated* (12), *copper, nickel-plated* (13); *furnace temperature,* 620°C.

In his latest published work[3] Schack gives heat transfer coefficients of iron in different furnaces, their dependence on the temperature of the gases being represented as linear above 700°C. for simplicity. The results may, however, be equally well represented by a cubic parabola, especially if those given by Trinks[4] be also taken into account. The latter results must be doubled to allow for the difference

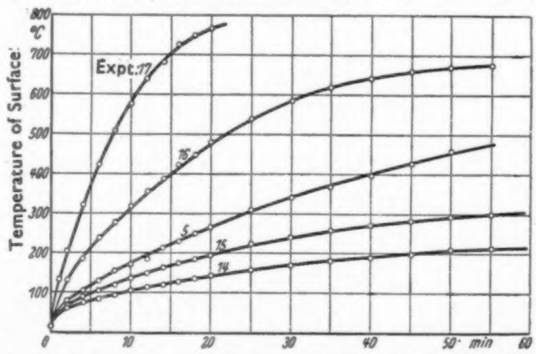


Fig. 7—*Copper; furnace temperatures,* 250°, 400°, 500°, 670°, *and* 825° C. *Experiments Nos.* 5, 14, 15, *and* 16, *with same test-piece. Experiment No.* 17 *with a smaller.*

in the surfaces considered. The curve obtained can be represented by the equation

$$\alpha = 0{\cdot}09\left(\frac{T_0}{100}\right)^3 = 10 \text{ Cals. per sq. metre per hour per degree} \quad \ldots \quad (11)$$

* The equation can be evaluated with two readings of the slide rule.

3 "Versuche über den Wärmeübergang in Walzerksöfen, Arch. *Eisenhuttenw*, Vol. 4 (1931), p. 333.

4 "Industrieöfen," *VDI-Verlag*, 1928.

The experimental values for iron in Series 2 and the values obtained by Koegel[5] and Netz[6] agree very well with the results given by this equation.

Works Experiments.

These experiments were used to decide the applicability of the laboratory results to works conditions. The results are reproduced in Table III and Figs. 10 to 13. The top, the two outer sides and one-third of the bottom of the pack were taken as the effective surface, as the back of the

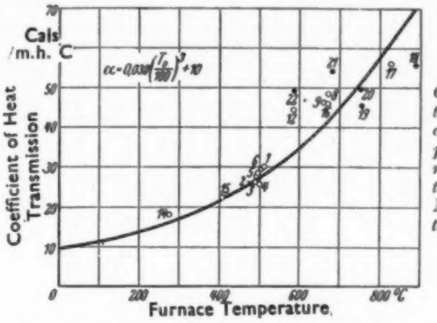


Fig. 8—Coefficients of heat transmission of aluminium, copper, and brass, relative to the effective surface. Numbers indicate the experiment number.

one pack was shaded by the neighbouring pack and the bearer rails covered about two-thirds of the bottom heating elements. The values obtained were very close to those of the laboratory experiments. The values for copper are somewhat above, those for brass below, the curve given by equation 10. The brass plates had a bright surface with a coefficient of radiation, calculated by Schack's method[7], of about 1·02; the experimental

TABLE III.
SERIES 5.—WORKS EXPERIMENTS.

Experiment Number	—	18	19	20	21	22
Carried out by	—	H.	H.	H.+W.	H.+W.	H.
Number of packs	—	1	6	6	6	6
Number of plates	—	2	5	5	4	4
Dimensions of plates	Mm.	950 × 620 × 90	950 × 610 × 90	950 × 610 × 90	640 × 620 × 100	640 × 620 × 100
Material	—	Brass	Brass	Brass	Copper	Copper
Effective surface per pack	M2	1·331	1·31	1·32	1·024	1·024
Weight per pack	Kilo.	890	2,250	2,200	1,350	1,350
Furnace temperature	° C.	900	750	753	680	580
Initial temperature	,,	20	20	25	20	20
Final temperature	,,	830	800	815	660	565
Increase in temperature	,,	810	780	790	640	545
Heat absorbed	Cals.	74,400	160,000	161,200	86,000	73,200
Time of heating	Hours	4·0	14·8	14·0	7·0	8·0
Specific heat load	Cals./m2, h	13,940	8,240	8,740	12,000	8,940
Mean surface temperature	°C.	640	570	580	460	400
Mean temperature difference	,,	250	180	175	220	180
$(t_m - t_1) : (t_0 - t_1)$	—	0·71	0·75	0·75	0·67	0·68
$(t_m - t_1) : (t_2 - t_1)$	—	0·65	0·71	0·70	0·69	0·70
Coefficient of heat transmission	Cals./m2, h_0	55·9	45·7	49·9	47·2	49·6

H. = Hoffmann. W = Wagener.

values, when used in equation 10, give C for brass as 0·975 to 0·985. The scattering is greater with copper, but considering the variability of works conditions, the

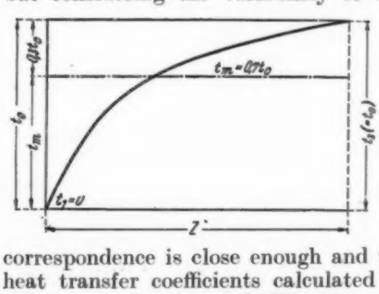


Fig. 9—Simplified representation of temperature relationship during reheating.

correspondence is close enough and the equations for the heat transfer coefficients calculated from the laboratory values may be accepted (Fig. 8).

Finally, the results may be compared with those in previously published work. In an article by Weiss[8] the heat transfer coefficient of copper is estimated at 15 to 43 Cals. per sq. metre per hour per degree relative to the total surface, but without further data. The effective surface in experiments 18 to 22 averaged 0·6 of the total; assuming the same furnace conditions, Weiss' figures relative to the effective surface would be 25 to 72, corresponding to the values at 400° and 900° in Fig. 10. Weiss' estimates thus serve very well as maximum and minimum

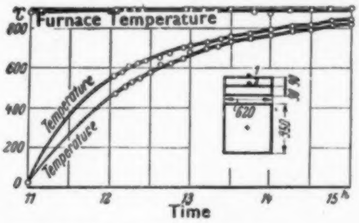


Fig. 10—Experiment 18. Two brass plates in annealing furnace.

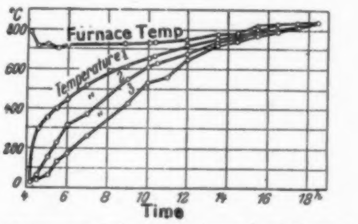


Fig. 11—Experiment 19. Brass, six packs of five plates each.

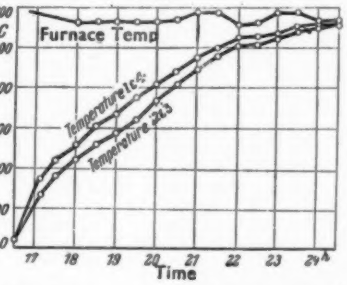


Fig. 13—Experiment 22. Copper, six packs of four plates each.

values for copper for the range under consideration. The heat transfer coefficients calculated from the results of Roth's experiments[9] on the reheating of brass sheet are 25 to 30 Cals. per sq. metre per hour per degree at 500° to 570°, these likewise agreeing with the values of equation 10.

In calculating the time of heating, the heat transfer coefficients are used in conjunction with Fig. 9 for constant, or for mean, furnace temperature t_0; where $t_1 > 0$ the expression

$$(t_m - t_1) = 0 \cdot 7 \ (t_0 - t_1)$$

must be used in place of $t_m = t_0$.

If the ingots do not reach the furnace temperature, then

$$(t_m - t_1) = 0 \cdot 7 \ (t_2 - t_1) \text{ approx. } \quad (10)$$

From $Q = Gc \ (t_2 - t_1)$ Cals.

and $Q = \alpha FZ \ (t_0 - t_m)$ Cals.

(where c is the specific heat in Cals. per kilo per degree)

$$Z = \frac{Gc \ (t_2 - t_1)}{\alpha F \ (t_0 - t_m)} \text{ hours,}$$

in which F is the effective surface of the material, and the

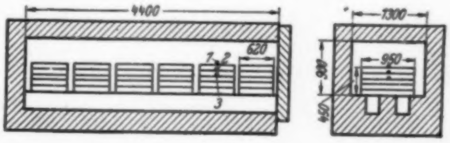


Fig. 12—Schematic representation of works experiments.

designations in Fig. 9 apply to the temperatures. Should the furnace temperature vary widely from place to place or from time to time, a mean value should be taken or a diagram should be obtained, so that the relevant mean value can be obtained from the course of the α-curve.

5 "Versuche über die Wärm-und Abkühlungsbedingungen von Blöcken," *Mittlg.d. Warmestelle*, V.D.E., No. 94.
6 "Die Wármeübergang im Stossöfen," *Mittlg. d. Warmestelle*, V.D.E. No. 81.
7 "Der industrielle Wärmeübergang," *Verlag Stahleisen*, 1929.
8 "Industrieöfen," *Z. VDI*, Vol. 70 (1926), p. 1,281.

9 "Das Eindringen der Wärme in die Glühhaufen beim Ausglühen von Messingblechen," *Z. Metallk.* Vol. 21 (1929), p. 414.
10 Where the difference in temperature at the end is very great $(t_m - t_1) = 0 \cdot 5 \ (t_2 - t_1)$ should be substituted.

The influence of radiation in heat transference at high temperatures should not be overlooked, and as much as possible of the surface of the material being heated should be exposed to radiation. Conduction, especially at low temperatures, is of greater significance with non-ferrous metals than with iron, being responsible for 46% of the total heat transmitted at 400° C., and for 18% at 800° C., as against 10% in the case of iron at 800° C. An improvement is thus more probable with non-ferrous metals than with iron. Thus, if a_c (equation 10) could be increased from 10 to 20 Cals. per sq. metre per hour per degree by stronger motion or turbulence of the heating gases or, in the electric furnace, by circulation of the air, the time of heating could be reduced by 15% at 800°, and by 30% at 400°. Heat transfer coefficients may probably be increased by blackening the surface of polished metals, thus increasing the absorption of radiation: experiments on this point are still incomplete.

Summary.

Laboratory and works experiments for the determination of heat transfer coefficients of aluminium, copper and brass are described. Radiation being less well absorbed by the bright surfaces of these metals, the coefficients are much lower than that of iron. The experimental results and the few data given in the literature can be summed up in the expression

$$a = 0 \cdot 03 \left(\frac{T_0}{100}\right)^3 + 10 \text{ Cals. per sq. metre per hour per degree,}$$

in which T is the furnace temperature in degrees absolute; this expression is valid for aluminium, copper and brass, the effective surface only being considered. In the same way the published figures for iron can be expressed by

$$a = 0 \cdot 09 \left(\frac{T_0}{100}\right)^3 + 10 \text{ Cals. per sq. metre per hour per degree.}$$

SAND - LIME BRICKS

The development of sand-lime bricks has a particular significance because of the use of blast-furnace slag in their manufacture, and a condensed description of the principles involved is given.

THE sand-lime process for the manufacture of bricks is of great interest to the metallurgical industries, because it enables blast-furnace slag and ash and clinker, as well as sand, to be made into high-grade bricks. In this connection considerable interest attaches to the recently issued Building Research Special Report, No. 21 (H.M. Stationery Office, 1s. 3d.), while a large sand-lime brick plant has just been completed at Holmethorpe, Redhill, Surrey, for the Standard Brick Co., Ltd., having a capacity of 600,000 bricks per week. The latest scientific principles are represented, and the plant throughout has been designed and constructed by Sutcliffe, Speakman and Co., Ltd., of Leigh, on somewhat similar lines to a plant of the same make that has been operating at Mansfield since 1926 for the Mansfield Standard Sand Co., Ltd.

Two of the main features of the new plant at Redhill are the extent of the mechanical handling and the elaborate methods of testing and general scientific control at all stages of the manufacture. This is to ensure that every brick can be certified and sold as Class A quality, according to the British Standards Specification, and all bricks, no matter of what type should only be purchased under conditions of a strict guarantee of quality. With regard to some of the advantages of the sand-lime process in general, the bricks are uniform in both quality and in size, with dead-straight surface and edges, having a dense, uniform structure, like smooth stone, entirely free from holes, cracks, and crevices. Also they are equal to the average burnt-clay brick in crushing strain and general resistance.

Efficient sand-lime brick-making plant must, however, be used, and of interest is that the above firm have supplied a considerable number of installations at home and abroad, E. R. Sutcliffe being one of the practical pioneers of the process. At Redhill the mechanical handling equipment has reached such a stage that the bricks, after leaving the press and being stacked on the trolleys for hardening, will not again be touched by hand, which reduces labour costs and eliminates risk of damage and breakage. The sand at Redhill is of particularly good quality—over 99% pure silica (SiO_2),—and the colour of the bricks is white, resulting in refractive properties and ability in many cases to replace glazed bricks.

In general the principle of the manufacture of sand-lime bricks is to mix sand intimately with finely divided slaked lime. The product having the correct moisture content is then made into brick shapes in a brick press, and the shapes are stacked on trolleys and heated in long, horizontal steel cylinders or autoclaves by direct steam blown in under considerable pressure. As a result the lime combines with part of the sand to form calcium silicates, which bind the shapes into a brick much harder than ordinary burnt-clay bricks.

The exact operating conditions depend upon the local circumstances, but roughly the composition of the sand-lime mixture for the brick presses is 85% sand, 8% lime, and 7% moisture (in combination). Also the steam heating is carried out at, say, 120–160 lb. per sq. in. pressure by means of an adjoining steam boiler for a period of about 4–8 hours, the bricks being ready for use immediately on cooling.

Authorities believe that a good grade of nickel or nickel-chromium cast iron will retain room temperature strength and load-carrying capacity practically indefinitely at temperatures up to 600° F. Of perhaps greatest importance is the fact that at these temperatures a gradual creep occurs in the metal, with the result that the load-carrying capacity over long periods decreases sharply. For instance, a 2,000-hour test on a nickel cast iron possessing 20 tons tensile strength at room temperature shows that its deformation rate in inches per inch reaches zero after 900 hours whereasa plain grey iron continues to creep up to 2,000 hours or the limit of this test. The load in this particular case was nearly five tons per square inch, or approximately 25 per cent. of the tensile strength.

A special drawing solution for lubricating the sheet and dies is required in forming stainless steel and strip. An empirical compound developed by a large automobile manufacturer was found to have excellent properties. It is merely a cup grease softened by paraffin oil, but bodied by such unctuous fillers as talc and lithopone. Sulphur is added, as it acts partly to keep the dies polished and in this way reduces scratches on the work.

Application of water-cooled holders to all tungsten carbide dies in the wire-drawing department of a mill has reduced the amount of cleaning appreciably. Since resorting to water cooling the dies remain in service five times longer without the necessity of returning them to the die room for cleaning, thus affording an increase in production.

The Classification, Properties, and Utilisation of Non-Ferrous Scrap Metals and Alloys—Part 3

By A SPECIAL CORRESPONDENT.

The wide variety of non-ferrous alloys now employed, and the increasing need for accuracy in their composition, creates a very real difficulty in their proper utilisation when the articles for which they have been used become scrap metal. In this, the concluding article of the series, the author discusses the problem with a view to the more profitable use of tin, lead, aluminium, and zinc scrap.

Scrap Tin Materials.

Scrap tin both in the form of pure unalloyed metal, and in the form of some alloys such as solder, and bearing metals, are among the most valuable scrap materials which may pass through merchants' and smelters' hands. At the present time tin is anywhere between £180 and £130 per ton, while brass may vary in price from £30 to £50 per ton. There is a certain amount of scrap tin tubings upon the market but this is getting steadily less every year since other cheaper substances have been used of late years for the conveyance of liquid in which there must be no contamination. Tin was at one time extensively used for the conveyance of beer or water and other liquids where there must be no question of the possibility of contamination from the metal. Such scrap tubings generally come from breweries and other similar plants. It is necessary, however, to exercise caution in buying such material since it is not infrequent to find that a composite tubing has often been used. This consists of an inner tubing of pure skin coated with a layer of pure lead to give additional strength. The melting loss of pure tin tubing is from 4 to 5%, and in exceptional cases may be as high as 6%. Tin-foil is not by any means always necessarily pure tin, and may contain from 3 to 30% of lead. There are many applications of foil where the purity from the point of view of poisoning does not matter, such as in the wrapping of tobacco where the use of pure tin would be wasteful and unnecessary. It such cases it is general to use an alloy of tin and lead high in lead. But for wrapping foodstuffs, such as cheese, it is general to use pure tin, otherwise there is fear of contamination of the food. Tin which had at one time been extensively and exclusively used for the wrapping of foodstuffs is now being displaced from its hitherto strong position by aluminium foil. Tin foil needs to be melted most carefully by submerging a little at a time under an already molten heel. If this precaution is not taken the melting loss is very considerable. A little resin or tallow may be thrown upon the surface of the melt at the end of the operation. Other tin-bearing materials include wiping solder, which analyses generally about 66% lead, 33%tin, and the highest grade of tinman's solder which analyses about 66% of tin and 33% of lead. For the determination of the tin content of solder it is usual to employ what it known as the solder scale which will give in a very few moments the composition of any lead-tin alloy without the necessity of resorting to analysis.

This testing is accomplished by weighing a small, specially produced ingot. Annother alloy containing a considerable proportion of tin is the well-known pewter, which often contains up to 85% of tin with 10% of lead and 5% of antimony and 1 or 2% of copper. The well-known Britannia metal, also sometimes called Babbit metal, contains about 90% of tin, 7·5% of antimony, and 2·5% of copper. It is not easy to distinguish pewter from Britannia metal by colour alone, but since it is not usual to use pewter in contact with foodstuffs on account of its 10% of lead, the purpose to which the article has been intended to be put is often a guide as to the composition. Britannia metal is generally made up into teapots, sugar-bowls, vases, ladles, waterjugs, plates, etc., and often these are silver plated. A low grade of pewter consists of 13% of antimony, with the remainder lead, but this alloy is only used for casting, whereas the alloy previously mentioned is also used for spinning and stamping. Stereotype metal generally contains a proportion of tin with antimony and a very little copper; the proportion of tin may be up to 60% with about 18% of antimony and the remainder lead. Electrotype metal generally does not contain more than about 5% of tin, with the remainder lead, antimony, and copper.

Lead Scrap Metals.

A number of the sources of scrap lead have already been mentioned in connection with the alloys of tin above. There is lead foil, lead piping, and lead sheet, which are all common sources of supply of the metal. Lead piping often contains antimony, and must not be regarded as pure metal on any account. It may also contain a little tin since these elements stiffen up the lead and tend also to make it less readily corroded. Lead is a very easy metal to melt, and should, in the molten state, be treated with tallow or resin as a flux in order to disentangle any dross which may be mixed with it. When an excessive amount of oxide from scrap lead is present in a melt the mass becomes rather pasty.

In order to overcome this difficulty it is general to hold a stick of green wood underneath the surface of the metal and allow it to burn away; in doing so it will clean the metal by reducing the oxide. Scrap lead and scrap tin are used to a very considerable extent for the production of solder, since solder made from such materials is cheaper than solder made from the virgin metals, and is from all points of view quite as satisfactory so long as the composition is accurately known. At one time, when tin cans were soldered thickly with ordinary tinman's solder, and were at the same time heavily tinned by the dipping process, it was usual to remove the tin and the solder from such scrap tin cans simultaneously by the process of stacking large numbers of the tin cans into a large open furnace with a fire buring on a grate at the bottom, and whereby the heat of the fire melted the tin and the solder from the cans and the metal ran out from beneath the firegrate into a pool underneath the whole furnace. Nowadays, however, so little tin is actually put on to the sheet steel for making tin cans, and generally solder is not used at all since the seam is formed mechanically, so that decreasing amount of tin and solder were obtainable by this process, until at length it was not commercially practicable to carry it on any longer. It is now general to remove tin from tin cans by chemical processes, such as treatment with chlorine, whereby chemical compounds of tin in the liquid form are obtained. Tin and lead-oxide drosses, residues, etc., are generally sold to the expert smelters for reduction back to the metal, since it is quite outside the scope of the ordinary small metal melter and refiner to obtain the metals from these refractory oxides. Solder which is thick in the melting pot is also thinned by holding green wood underneath the surface, whereby the gases which are generated reduce the oxide to some extent. This is just in line with the process already described for the treatment of lead scrap metal in the melting pot. It is also for this purpose beneficial sometimes to use sulphur, resin, sal-ammoniac, or a mixture of all three for the same purposes.

When solder or lead contains a small proportion of zinc this metal may be removed by stirring in sulphur and then

treating the thick scum which results with a small proportion of resin. This operation converts the scum into a black dust or dross which can be removed from the surface and sold to smelters. If the solder runs freely in strip moulds it is not necessary to flux it at all, but if difficulty is experienced in this way it is usual to use some such flux as a mixture consisting of 35% sal-ammoniac, 35% fine powdered charcoal, and 15% each of sulphur and resin. This mixture is stirred into the molten metal just before pouring. The influence of antimony in solder is apparently open to some question since it is claimed by some authorities that the antimony should not exceed 0·5%, while others say that 2% effects no serious harm. There is no doubt, however, that a small proportion of antimony considerably improves the surface appearance of solder and makes a selling price of considerable importance. The working properties of solder containing antimony, however, are not improved. Drosses resulting from solder, lead, tin, and similar white metal melting operations are generally smelted in reverberatory or open-flame furnaces, together with a small proportion of acid sodium sulphate and wrought iron. Coal is used as a reducing agent, and the products of this operation are white metal and a dross or mat which contains most of the infusible impurities. This operation is conducted at a high temperature, and on this account a certain amount of iron and other high melting point metals are also taken into solution. The ingots which are obtained by this process are then subsequently sweated on an inclined hearth at a low temperature, whereby the lead, tin, and antimony run down the inclined hearth into a sump at the bottom and leave behind iron, nickel, and copper, combined with sulphur as impurities upon the inclined hearth. These latter materials may be treated separately or sold to experts in the smelting of nickel or copper.

Aluminium Scrap Metals.

The scrap aluminium industry is one of the largest scrap metal businesses in existence; it has grown up relatively rapidly, but has far eclipsed all other scrap metal industries in magnitude, with the exception, of course, of the iron and steep scrap metal industries. The scrap aluminium and aluminium alloys materials are, of course, too numerous to mention here, and include, roughly, sheet metal, both pure and alloyed, stampings, spinnings, castings, and drosses. There is also an increasing amount of aluminium wire scrap appearing upon the market since aluminium wire and cable is now used with increasing extent for the overhead transmission of electrical power in place of copper previously used exclusively for this purpose. Such scrap metals may all be melted in reverberatory or open-flame furnaces, or if higher extraction figures are desired at the extent of output, crucible or iron pot melting is satisfactory. Scrap sheet pure metal is generally used directly for the production of alloys in the foundry, or it may be made up into ingots by the secondary metal producers and sold either as pure metal or as definite standard alloy. Cast scrap generally is run down in large open-flame furnaces well mixed, fluxed, and tapped out into parcels, each of the parcels is analysed and remelted together with the necessary alloying elements, and a certain proportion of pure metal to produce ingots of definite specification composition. Wrought aluminium alloys in the form of sheet and stampings, such as duralumin and other wrought alloys, are treated similarly. These melting operations can be conducted without appreciable loss, but on account of the affinity of aluminium and its alloys for oxygen while the metal is in the molten state, the loss is higher considerably than in the case of melting brass scrap. A melting loss on aluminium wire or sheet may be anything from 5–15%; on the melting of castings the loss should be considerably less since the bulk of these is generally greater. Scrap aluminium in the form of machine-shop swarf or turnings constitutes an important form of waste material. The melting of this material presents considerable difficulty if high extraction figures are to be obtained. Such materials are usually puddled or rabbled into a pasty heel maintained in the bottom of an iron pot; more material is added and the temperature rises so as to keep the temperature of the metal low during the whole operation, when the pot is eventually filled completely with pasty metal which has been rabbled in little by little; the temperature is then slightly raised and zinc chloride is stirred in, when after a little more rabbling and working the extrained oxide will rise to the surface as a dry, dusty powder which can be skimmed off from the molten layer beneath. The metal is then ingotted out, leaving, however, a little molten metal in the bottom of the pot so as to enable the operator to start the operation over again. Where vast quantities of material of this kind have to be treated, as in America, it is usual to charge the material very often automatically beneath the surface of metal in a large furnace, using as a molten flux cover some such mixture as 50 : 50 sodium chloride and cryolite. In the relatively smaller scale operation, which is commercially possible in England and in Europe generally, the treatment of this material is often accomplished in iron melting-pots. The melting-pots may be rabbled by hand by one man, but the labour is very tiring and hot, and it is preferable where possible to install mechanical apparatus for this purpose. Furnaces should also be well equipped with hoods provided with a fan so as to draw the unpleasant vapours and dust from the melting, fluxing, and skimming operations. The dry, dusty oxide which is removed from the molten metal should be spread out upon iron plates in an open space as soon as it has been skimmed from the surface of the metal; it will then cool rapidly, and can later be riddled through fine sieves in order to separate the last remaining shots of metal from the actual aluminium oxide powder which will pass through the sieve; this latter can also be sold to chemical manufacturers, who use it for the production of aluminium sulphate used in the manufacture of size for paper. The metallic shots which remain upon the riddles may be remelted for the aluminium content. Such ingotted material is all then melted together in a large reverberatory furnace, and analysed and made up to specification analyses. Sheet, clippings and fine spinnings, should preferably be baled or briquetted before melting, since in this way the oxidation loss is considerably reduced, and the material is, additionally, made much more convenient for handling in the melting furnaces. There does not appear to be much advantage to be gained from the briquetting of machine-shops warf or emery grindings; such material should be melted, as has already been indicated. Emery grindings present a rather serious problem, and extraction tends to be very low unless the melting is conducted carefully; it is often preferable to sell such material directly to chemical manufacturers, who will extract the aluminium content by chemical means.

Zinc Scrap.

A certain amount of zinc scrap appears upon the market from gutterings, from roofing contractors and plumbers, also from the spent electrodes from batteries, and from other sources. Scrap zinc may be melted in an iron pot, but preferably it is melted in a crucible since there is some tendency to attack the iron pot as in galvanising. When melting zinc scrap the bath tends to become thick and pasty. It may be thinned, however, by introducing by means of a phosphoriser, a mixture of sulphur, raw potatoes, and scrap leather, cut up and mixed together, and stirred under the surface of the molten metal for 15–30 minutes. Only small amounts of this mixture can be used at a time, otherwise metal will be scattered out of the pot. The presence of iron in zinc renders the metal thick and pasty, and the procedure outlined above will, to some extent, remove the iron. It can be taken fairly definitely for granted that zinc, which runs fluid in the ingot mould, is relatively pure.

American Society for Testing Materials

Thirty-seventh Annual Meeting.

WITH a registration of 825, which greatly exceeded that for the past two years, and an unusually large number of committee meetings —viz., 175 — the thirty-seventh annual meeting of the A.S.T.M., held in Atlantic City recently, was extremely active. Fifteen formal sessions were held, at which ninety technical papers and reports were presented. As a result of actions at the meeting, some thirty-five proposed standards were accepted for publication as tentative, and upwards of forty existing tentative specifications and test methods were recommended for adoption as standard. These latter items, with, in addition, thirteen revisions in standards, will be submitted for formal adoption. In this report it is only possible to discuss briefly the work presented at three of the sessions.

Non-ferrous Metal.

An outstanding report was presented on light metals and alloys, representing an exhaustive compilation of data on the service characteristics of light metals and alloys. Its purpose is to provide the engineering profession with an accurate picture of the light metal industry, discussing aluminium and magnesium and alloys under such heads as metallurgical characteristics, industrial requirements, surface protection, and tabular data. The latter involve some seventeen tables, giving valuable information on physical and mechanical properties, compositions, etc.

The impact strength of commercial zinc alloy die castings was discussed by E. A. Anderson and G. L. Werley. The question has been frequently raised as to whether properties of commercial die castings approximate those of test specimens cast to size. The impact tests were carried out on over 500 test-bars, machined from 77 commercial die castings. All of the specimens tested were cut so as to include one unmachined die-cast face, and in the test this face was always in tension. The authors conclude that so far as impact strength is concerned, close agreement exists between properties of die-cast bars and of sections cut from the surface of die castings. No further conclusions were drawn from the extensive data. It was pointed out that with the exception of three parts, the specimens represented at least one-half of the total thickness of the castings investigated.

New specifications were recommended for magnesium-base alloy die castings, and these were approved by the Society session as an A.S.T.M. tentative standard. The committee dealing with the subject has conducted a questionnaire to determine whether there exists sufficient demand to justify specifications covering ingots intended for the manufacture of die castings. The replies indicate that such specifications would supply a very definite need, and the committee contemplates the addition of other ingot alloys to existing specifications for aluminium-base sand-casting alloys in ingot form.

Appended to the report of this latter committee was a paper dealing with the effect of variations in aluminium content on the strength and permanence of the A.S.T.M. No. XXIII. zinc die-casting alloy. Ever since the commercial introduction of this alloy, there has been a pronounced desire to increase aluminium content in the interest of better castability. Of the properties measured, the impact strength was most important, and as a result of the ten-day steam test, which is claimed to be the most practical means of evaluating the permanence of impact strength, it was indicated that the aluminium content of the alloy should be definitely limited to a maximum of 4·4%. It is not unusual to find deviations of 0·1% from the true aluminium content, and for this reason the authors favour placing the maximum at 4·3%. Whereas this work was started in an effort to find out whether the maximum limit for this alloy could be raised, the tests indicate the desirability of a reduction from the present value, 4·5, to the lower value, 4·3.

Some factors affecting strain measurements in tests of metals was the subject of a paper by R. L. Templin, based on results of a large number of tests carried out to afford a comparison of deformations on various elements of both tension and compression specimens of various forms in both the elastic and plastic ranges. The metals used for the tests were high-strength wrought aluminium alloys, but quite similar results would be anticipated with any other metals having similar stress-strain characteristics, such as cold-worked copper or steel, nickel, alloys of magnesium, stainless steel, and others. After describing the tests and summarising the results, Mr. Templin concluded that considerable variations in strain and stress are to be anticipated in both tension and compression specimens, even using careful technique and good apparatus, but the results indicated definitely the necessity for uniform and axial loading of specimens.

A note on frictional resistance of steel and brass in shrink fits, given by W. H. Swanger, was of particular interest. The making of shrink fits by refrigerating the inner member offers an easily accomplished alternative when the converse method of expanding the outer member by heat is not practicable or permissible. In Mr. Swanger's investigations he used three combinations of material, namely, a brass ring on a brass pin ; a steel ring on a brass pin ; and a steel ring on a steel pin. The cylindrical rings were 1 in. long and 1 in. in internal diameter, assembled on pins which at room temperature were about 0·0015 in. larger in diameter. As a result of the experiments, it was indicated that in shrink fits made by cooling the inner member, seizing does not occur until relative motion has taken place between the two contacting surfaces, and after seizing has occurred, the force necessary to continue the separation of the fitted parts is very much increased. For example, the first combination mentioned supported a load of 2,200 lb. before initial slip occurred. A maximum of 4,370 lb. was required to continue slippage. For a steel ring on a brass pin, the initial slip did not take place until a load of 5,400 lb. had been applied and a maximum of 6,800 lb. was reached to continue slippage. The steel ring on the steel pin did not slip until a load of 5,725 lb. was applied, and as in the two other cases, the load decreased immediately but then increased rapidly until a maximum of 19,000 lb. was reached. The failure of the brass to seize was undoubtedly associated with the particles of metallic lead disseminated throughout the alloy, whereas the presence of the brittle sulphide particles in the steel is responsible, at least in part, for the tendency of the steel to score the brass, according to Mr. Swanger.

Ferrous Metals.

The results of an extensive investigation of the effect of size and shape of test specimens upon the tensile strength, elongation in 2-in. gauge length, and reduction of area of structural steel were given in a paper by Messrs. Lyse and Keyser. The specimens varied from ¼ in. to 1 in. diameter bars, and from ¼ in. × ¼ in. to 1 in. × 4 in. rectangular sections, which were machined from ¼ in., ½ in., and 1 in. thick plates from the same heat of structural steel. The authors conclude that size and shape of test specimens had practically no effect upon Johnson's limit or tensile strength, while elongation in 2 in. increased with the size

of the specimen. Reduction of area decreased with an increase in the ratio of width to thickness of the rectangular specimens, but was nearly constant for bars of different diameters.

Discussing blue brittleness and stability of sheets against changes due to ageing, R. L. Kenyon and R. S. Burns indicated a quantitative relationship between the difference between tensile strength at room temperature and that determined at 400° F., as correlated with the change in tensile properties of cold-rolled sheets due to artificial ageing treatment. The method they described for evaluating ageing properties by determining the tensile strength at room temperature and tensile strength at a temperature in the blue-brittle range is a relatively rapid one. The authors state that a large number of materials have been tested, and in practically all cases it was possible to predict whether the material would age after cold-rolling.

The existing tentative specifications for bridge and building steel of the so-called medium structural grade were recommended to be adopted as standard. New specifications for electric fusion-welded steel pipe for high-temperature and high-pressure service were approved as tentative. These provide for three grades of material, with minimum tensile strengths of 45,000, 50,000, and 55,000 lb. per sq. in. respectively. The committee dealing with this work has a number of specifications which will probably be submitted to the Society during the summer for approval as tentative, including requirements for pipe and castings for use at temperatures up to 1,100° F. An investigation is under way which may result in definite recommendations for inspecting and controlling surface imperfection in structural steel, especially the heavier sections. Changes which were approved in the specifications covering black and hot-dip zinc-coated welded and seamless steel pipe provide badly needed galvanizing requirements.

A report on quality standards on which work has been proceeding for over two years was presented by the committee on wrought iron. This discusses physical properties, chemical analysis, and structural characteristics of the material. Since use of the microscope has become a most useful adjunct in studying this material and fixing quality standards, this is discussed, and a number of typical microstructures are illustrated. On the basis of this report extensive revisions in the standard specifications for wrought-iron plates were recommended and approved.

A method of sampling molybdenum salts and compounds for metallurgical use was approved as a tentative standard upon the recommendation of the Society's committee on ferro alloys, and the proposal to adopt as standard existing tentative specifications covering ferromolybdenum and ferrotungsten and low-carbon ferromolybdenum was approved.

The Joint Committee on Investigation of the effect of phosphorus and sulphur in steel has been investigated, and the results summarised of laboratory tests of four heats of low-carbon steel of progressively increasing phosphorus content. This is of importance, due to the commercial practice of re-phosphorising in the manufacture of welded steel pipe. Phosphorus contents were respectively 0·007, 0·051, 0·060, 0·080. Tests showed an increase in tensile strength and elongation, with increase in sulphur content, but the proportional limit and reduction of area did not establish such relationship. Within the limits of phosphorus content used, the steels were not adversely affected in cold bending in the as-received or annealed condition, but an adverse effect was noted in the quenched condition. A very satisfactory degree of uniformity was noted between tensile properties determined longitudinally and transversely to the direction of rolling.

Two papers presented at the meeting involved corrosion of ferrous materials. K. H. Logan discussed the use of Bureau of Standards soil corrosion data in the design and protection of pipe lines. He mentioned that soils control to a large extent the corrosion of existing pipe-lines. While the work has brought to light many new and useful facts, further work is required to determine the significance of certain tendencies shown by the data, notably the effects of size and age of the specimen on which pitting measurements were made, the protective effects of corrosion products, and the results of departure from homogeneity of the soil with respect to its physical characteristics. Waldron and Groesbeck discussed observations on effect of surface finish on the initial corrosion of steel under water. They indicate that in general the type of finish is not an important consideration at low velocities of flow, but is at high velocities, this conclusion being based on results of a relatively short period of immersion.

The results of investigations made during the past year at the various test sites were given by the committee on corrosion of iron and steel. One of the sub-groups is developing urgently-needed methods for determining the weights of electro-deposited coatings. Because of irregular and uncertain results thus far obtained by technologists on the effect of compositions of ferrous metals on under-water corrosion, another series of tests will probably clear up certain undecided points. During the year greatly increased interest on the part of consumers of farm-fencing has been aroused, and this, with the field tests, is expected to result in decided improvements in specifications for these materials.

Effect of Temperature on Metals.

A paper on the interpretation of creep tests, by P. G. McVetty, discussed the fundamental nature of the creep curve and the effect upon it of strain-hardening, annealing, and other phenomena connected with long exposure of complex alloys to stress at elevated temperatures. Examples were given by Mr. McVetty to show how under suitable conditions creep data may be correlated. He mentioned that creep tests must be extrapolated if they are to have design value, and the time ratio may be as great as 100 to 1. Granting all the objections to extrapolation, it may be looked upon as a necessary evil.

In an interesting discussion of creep properties of 5% chromium and 0·5% molybdenum steel tubes, Messrs. Cross and Johnson pointed out factors of interest to producer and consumer alike—namely, the effect of carbon content, heat-treatment, and variation of directional properties resulting from working during fabrication. Increase in carbon content from 0·139 to 0·181% in a 4–6% chromium, 0·50% molybdenum steel increased the physical properties and creep resistance materially. Longitudinal material showed better creep resistance than transverse material of either carbon content, but the differences were less than 10%. In comparing normalised and slow-cooled materials, the latter developed better creep properties. Impact resistance of transverse material was lower than for longitudinal material. Impact tests made on specimens subjected to load and temperature for 1,000 hours or more, revealed no notable drop in toughness. With some of the structures resulting from initial heat-treatment, a slight reduction was noted, but a large measure of toughness remained.

The ageing embrittlement of 4 to 6% chromium steel was discussed by Messrs. H. M. Wilton and E. S. Dixon. This steel, with low carbon content, is being extensively used in oil refineries in the form of heater tubes, and it is at times subject to embrittlement after exposure to operating temperatures (approximately 900° F.) and cooling when the plant is shut down. The authors conclude that normal failure of this steel in refinery use is accompanied by creep, with visible swelling, and that most heats show high degree of susceptibility to temper brittleness. From a theoretical viewpoint it is concluded that embrittlement is revealed by a drop in impact value, with, at most, only a negligible increase in hardness or tensile strength.

Progress in Tin Research

The first general report of the International Tin Research and Development Council, recently published, and reviewed in this article, describes the organisation and progress of this body, which was established by the Governments and tin producers of the principal countries exporting the metal.

TIN, as is well known, has certain unique characteristics which make it almost indispensable for certain industries. The atmosphere has little action upon it, and the metal is resistant to many substances, organic as well as inorganic, so that it is used largely as tinplate for making food containers. In addition, however, tin is used in the manufacture of terne plate, sometimes known as roofing tin, for solder, babbitt and bearing metals, brasses and bronzes, type metal, foil, collapsible tubes, and chemicals; while further applications include tin in steel and nickel alloys, and tin electrodes in dry electrical accumulators. To acquire and disseminate scientific and technical knowledge relating to tin and its various applications, the International Tin Research and Development Council was established. The objects of researches and other activities of this Council are to discover and develop new industrial applications of tin, to improve existing products and processes, and to assist tin consumers in overcoming technical difficulties and problems relating to tin.

In planning the researches which are at present under investigation, the main policy which has been adopted is to serve the needs of the industries connected with the existing markets for products containing tin, and at the same time to conduct fundamental researches on the properties and reactions of tin in order to develop new outlets in the future. There is great need of a vigorous and extensive plan of research, aiming at the improvement of tin products, particularly by means of researches of a fundamental character, into the nature of the products and processes involved, and, as the report recently published by the Council shows, considerable progress is being made in this direction.

The researches already in progress have been planned to investigate basic problems in all the major applications of tin. The main points requiring investigation and the progress of the researches being conducted on each of these chief lines of investigation are described in the report, which discusses the research work under separate headings, according to its field for the consumption of tin. Thus, the subject of tinplate, which forms by far the greatest outlet for tin, is considered separately.

Tinplate.

Tinplate is used for a wide variety of applications owing to its good appearance, lightness, ductility, ease of soldering and seaming, and especially its suitability for mass-production processes. These qualities should result not merely in the maintenance of the large existing market, but should lead to its further expansion in view of present industrial trends. On the other hand, even the best tinplate is not perfect and this tends to retard expansion, and even to encourage contraction in certain important applications. There is, therefore, a field of research of very great importance to the tin industry in the direction of improving the tin coating on tinplate.

The Council's chief researches on tinplate, which have been carried out after discussions with tinplate manufacturers, can makers, and canning research establishments, fall into three groups :—

1. Researches on defects which are present in tinplate as manufactured.
2. Researches on the further defects that are produced when tinplate is deformed—*e.g.*, during the process of can manufacture.
3. Researches on the behaviour of tinplate in contact with various corrosive media, particularly of the type met in canned foodstuffs.

A brief account of the chief developments along these three lines of investigation is given in the report, which shows that definite additions have been made to the scientific knowledge of tinplate as regards methods of testing, structure, and defects arising during manufacture or during subsequent fabrication. Collaboration has been established with important organisations in several countries in the development of a greatly improved tinplate, arising out of improved technique in rolling the steel and a closer control of its composition. Increased knowledge of the corrosion of tinplate has been acquired, especially under the conditions obtaining in the canning industry, which is leading to progress in overcoming the corrosion of the tinplate container.

Solders.

Next to tinplate the tonnage of tin used in solders makes this an important field that demands attention. A considerable amount of attention has been devoted to solder by various technical bodies, and compositions of solders have been specified for different types of work. In various specifications amounts of antimony up to 3% are permitted. Since 1% of antimony replaces 2% of tin, this means that several important classes of solders have their tin content reduced by as much as 6%. Further, the authorisation of relatively high antimony content encourages the use of a considerable amount of secondary or recovered tin in the manufacture of solder. In this connection the nature of tests used to evaluate the suitability of solders for various purposes is important. In most cases the strength of a soldered joint can be determined by ordinary physical tests; there are, however, applications in which solders and soldered joints are subjected to vibration, which may cause failure by fatigue. The resistance of solders to corrosion is also important, and researches in these directions are in progress.

Bearing Metals.

This section is devoted entirely to white-metal alloys, and in view of recent developments, particularly of the internal-combustion engine, and the wide field of application of this type of power unit, the Council have been primarily concerned with the improvement of high tin-base alloys for severe service. At the same time they cover other lines of investigation which will provide data of value in respect to almost the whole field of application of tin in bearing metals. These contribute to fundamental and practical knowledge concerning tin-base bearing metals. In addition, new methods of physical testing of bearing metals have been devised and new bearing testing machines evolved. Enhanced properties of tin-base bearing metals, particularly by addition of new alloying metals, have been obtained to meet recent developments in engine design.

Bronzes.

Bronzes constitute an important outlet for tin. They include a large number of alloys, which may be classified broadly, according to their applications, in the following three sections :—

I. Bearing bronzes.
II. General casting alloys for engineering and other purposes.
III. Bronzes for fabrication into tubes, wire, rod, strip, and sheet.

In each of these sections research work is in progress. Investigations relating to the improvement of the design of bronze bearings for instance. With regard to bronze liners, an analysis of the stresses to which white-metal

coatings are subjected in service has been made, and definite advantages of certain heat-treated bronze liners have been indicated. In general casting bronzes an important line of research in progress is directed towards the elimination of internal porosity. Work was begun to study the effect of small additions of various elements. In the course of this work much new information has been acquired, as in all cases where additions were made the structure and mechanical properties of the alloys have been determined.

Arising out of this work it has been found that by small additions of a suitable metal it is possible to ensure that the bronze gives gas-free castings, in which shrinking is less serious than in the untreated bronzes. Sand castings of this alloy have a clean surface, and a pleasing colour, and come away easily from the sand. In view of these interesting results, arrangements have been made for tests under semi-industrial conditions.

Even after all possible improvements have been effected, straight tin bronzes will remain unsuitable for certain applications in which their rivals are becoming increasingly employed. Such applications are those demanding high resistance to various corrosive media, and good mechanical properties at ordinary and elevated temperatures. There is, therefore, an important field for complex bronzes containing other elements in conjunction with tin. In view of the inadequacy of the data available, it would be inadvisable to embark on a systematic investigation of the whole field, and it was decided to concentrate initially on certain specific lines :—

(1) Condenser tubes. This is a very important outlet for materials resistant to sea water and fresh water, for service in marine engineering and land power-stations.

(2) Materials for use in contact with various reagents in chemical plant.

(3) Material for plant handling foodstuffs.

In all these applications the service behaviour is so important that the user is prepared to pay a good price for a high-quality product.

A research is being planned on the die-casting of tin bronzes. At present the difficulty of casting bronze in this way, which is very suitable for mass-production articles, is giving a great advantage to other materials. Specific inquiries on this subject have been received from various manufacturers in different countries. Generally, however, increased metallurgical knowledge has already been acquired concerning tin bronzes for sand- and die-casting and fabrication, particularly in the direction of overcoming fundamental defects which encourage the use of substitutes.

Hot-Tinning.

Hot-tinned coatings on cast-iron steel copper, etc., form an important outlet for tin but the manufacturing processes have, up to the present time, been conducted almost entirely by rule-of-thumb methods. The most important application of tinned copper and steel is in the dairy, brewing, and other food industries, whilst a considerable amount of tinned copper wire is produced for use in the electrical industry.

The chief defects produced in the tinning operation are pin-holes and unevenness of the surface, whilst in service the materials suffer from rapid wear by abrasion and cleaning operations and from corrosion in contact with various substances. These difficulties have led to increasing competition in all the applications of tinned ware, and a more satisfactory coating is demanded if this competition is to be overcome.

As a result of investigations, substantial advances have been made in acquiring knowledge of the factors influencing the continuity and evenness of tin coatings produced by hot-tinning. This has involved developments in testing procedure for evaluating the quality of the coatings, the influence of fluxes, etc. In the light of this knowledge the possibility of securing improvements in tinning technique is being actively followed. Progress has also been made in the development of harder tin coatings to withstand abrasion in food industries, etc., by adding non-toxic elements, while promising improvement in the resistance of tin to attack by beer has been secured by the addition of a suitable alloying constituent.

It has been possible to refer only very briefly to the wide service which the Council's organisation has been able to render in the supply of technical information to manufacturers and scientific investigators in many countries.

It is noteworthy, however, that a special bureau of technical information has been established to assist manufacturers and investigators and for the publication of the results of research and development. Readers are advised to obtain a copy of this report, which describes the Council's wide service more fully. The address is The International Tin Research and Development Council, 378, Strand, London, W.C. 2.

World Tin Consumption—Record Tinplate Figures.

The July *Bulletin* of the Hague Office of the International Tin Research and Development Council reveals the fact that the consumption of tin in the world's tinplate industry reached the highest figure recorded at 55,000 tons for the year ending May, 1934, being 5,000 tons more than in 1929, and 2,800 tons more than in the peak year of 1933.

World automobile production for the first five months of this year compares with the same period last year as follows :—

1933	1,076,282 units.
1934	1,835,030 units.

The tin consumed by this industry for the same period being 3,590 tons in 1933 and 5,700 tons in 1934.

The world total consumption of tin during the 12 months under review shows an increase of 27% over the preceding year. Consumption by various countries is shown in the following table :—

Twelve Months ending May.	1933.	1934.
	Long Tons.	
U.S.A.	38,470	58,117
U.K.	17,879	20,112
Germany	8,872	11,007
France	9,826	9,554
Italy	3,753	4,020
U.S.S.R.	2,676	5,153
British India	2,051	1,900
Total	83,527	109,863
Total (World)	101,765	129,600

Babbitt metal consumption had increased by 64% during the last 12 months, as compared with the previous year.

Reopening of First Blast-furnace of Magnitogorsk.

The first blast-furnace of the Magnitogorsk Metallurgical Works has again been put into operation after considerable reconstruction. When the furnace was first started in January, 1932, Stalin called it "unique," as it was the only one of its type in the U.S.S.R. both in size and technique. Since then three other large blast furnaces each of 1,000 to 1,200 tons capacity have been built at Magnitogorsk.

Blast-furnace No. 1 has been used for educational purposes for Magnitogorsk metallurgists. The Soviet workers who led the construction and assembly work had had no previous experience, and were dependent for advice on American experts. The furnace was blown under severe frost before construction was entirely completed, and without a sufficient number of skilled workers. The result was that the average daily production of the furnace did not exceed 206 tons during the first month, and took four months to reach 850 tons. Blast-furnace No. 2, which was put into operation in the summer of 1932, was more successful. Furnace No. 3, which began operation a year later, achieved an average daily output of 864 tons in the first month. In the second month it had a daily output of 1,150 tons.

Before reconstruction, blast-furnace No. 1 worked irregularly, and frequent stoppages for repairs were necessary. It is now hoped that uninterrupted work, equal to that of the other three furnaces, is now assured. The total output of all the furnaces should amount to 4,000 to 4,500 tons of cast iron daily, or 15% of the entire output of the U.S.S.R.

Recent Developments in Tools and Equipment

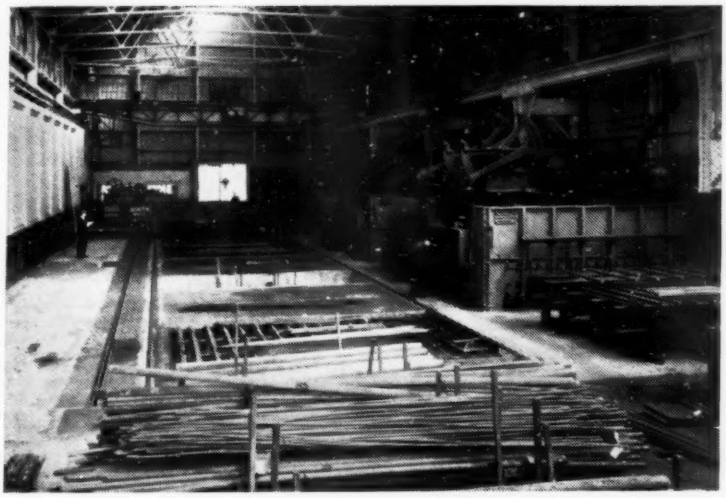


Fig. 1.—Heat-treatment section equipped with three town gas fired regenerative furnaces.

Black and Bright Steel-bar Plant Installation.

THE increasing need for meeting the increasing demands for both bright and black steel bars for the aircraft, automobile, and general engineering industries from stock, has caused the English Steel Corporation, Ltd. to instal, at the Vickers Works, a new and modern plant for heat-treating, warehousing, cold-drawing and centreless grinding the steel which they manufacture. This development is part of the scheme of reorganisation which has been in progress for some considerable time, but, while space has been allowed for new machines in the planning of the new department, the demand for these steels necessitated the immediate installation of the machines, so as to facilitate the service. The plant has several interesting features which are noteworthy, as will be appreciated from the following brief description.

Heat-treatment Section.

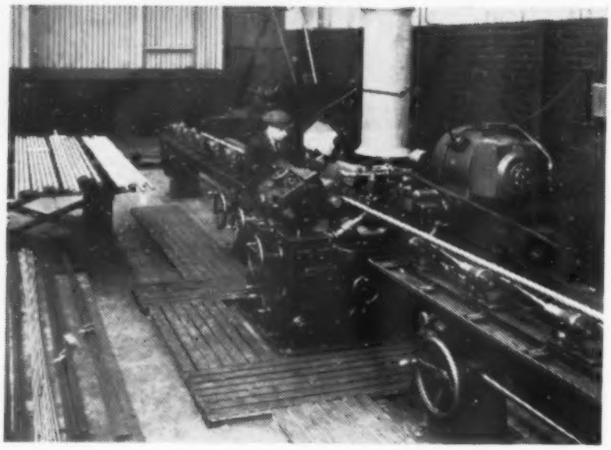
In this section three large generative furnaces are installed. Fired by town's gas, they are capable of working at a temperature up to 1,200° C., with a heavy reducing atmosphere, thus ensuring the heat-treatment of bars being carried out with a minimum of scaling. These furnaces, Fig. 1, which were built by Messrs. Priest Furnaces Ltd., are charged and discharged by an electrically-operated ground-type charging machine running on a rail track in front of the furnaces and treatment tanks, and capable of handling loads up to four tons in weight. The general arrangements being shown in Fig. 2. The method of operation is for the furnace charge to be prepared on stationary loading tables by electric overhead crane, the bars being supported on heat-resisting steel bearers. The charge and bearer bars are lifted bodily by the charging machine, then transferred into the furnace, and deposited on the hearth, the "peel" of the charging machine is withdrawn through slots in the furnace hearth after depositing the charge. When discharging the process is reversed.

Quenching in oil, or water, is carried out mechanically. The charge is withdrawn from the furnace, and transferred by the charging machine on to a specially-designed skip suspended over the treatment tanks. These skips are operated by electric hydraulic gear. The whole operation of transferring a charge from the furnace and immersing in oil or water can be performed in 35 secs. for any load up to four tons. By this method of mechanical handling, the bar stock is entirely supported during the whole of the treatment operations and, in consequence, distortion and subsequent excessive cold straightening is, to a great extent, eliminated.

The furnaces are capable of treating bars up to 6 in. diameter by 16 ft. long, and each is thermostatically controlled and equipped with the latest type Electroflo recording and indicating gear. For instance, each furnace is fitted with four 4-ft.-long thermocouples, which are arranged so that they can be raised for loading and unloading, and lowered directly on the work during heat-treatment, in order to obtain the actual temperature of the work. One thermocouple is connected to an indicating control pyrometer—the three others being connected to a three-point recorder, with a continuous strip chart 6 in. wide.

The three recorders are mounted on a panel in the shop office, and the three controllers on a panel at the side of one of the furnaces. The controller panel carries, in addition to the three control pyrometers, three Electroflo patent broken thermocouple safety devices, designed to cut off the fuel supply to the furnace should the thermocouple fail for any reason or at any time. Each controller is furnished with a red and green signal light, showing whether the temperature is high or low. The recording pyrometers produce three records, one in red, one in black

Fig 2.—Showing arrangements for handling charges to be treated



One of the centreless grinders, capable of grinding bars from $\frac{1}{16}''$ up to 4″ diameter to precision limits, in lengths up to 30 feet.

and one in green, readily distinguishable from each other and corresponding to the back, centre and front of the furnace, and thus enabling a very uniform temperature to be maintained continuously in all parts of the furnace.

The three control pyrometers each operate electrically two Electroflo valve regulators, one to operate the 4-in.-diameter air valve and the 4-in.-diameter gas valve, and the other to operate the 8-in.-diameter exhaust valve, which controls the suction from the furnace. In this way not only can the temperature be controlled within very fine limits, but the atmosphere is kept constant—a most important point in heat-treatment.

It is noteworthy that auxiliary oil and water tanks are provided between the charger track in front of the furnaces for the treatment of oddments and specialities which cannot be conveniently handled in bulk with the charging machine. The whole plant is accommodated in a well-lighted building 150 ft. long by 60 ft. span, and is entirely free from smoke and dirt usually associated with installations of this nature, and is, in fact, a complete revolution in heat-treatment practice. The shop is served by a 10-ton overhead electric travelling crane, and the layout is such that both ingoing and outgoing material can be dealt with by road transport or rail. This section is immediately adjacent to the special steel warehouse and grinding and drawing bays, to which stock can be transferred by transfer tracks at each end of the shop.

Special Steel Warehouse.

This section is situated between the heat-treatment bay and the grinding and bright-drawing bays, and is so arranged that stock can be conveniently transferred to the latter sections. It has been specially designed and equipped to deal with the output of the heat-treatment department, and the layout so arranged that the operations of examination, testing for quality by spark and spectroscope, straightening, sawing, cropping and despatching can be carried out in proper sequence with a minimum of handling. This shop is 150 ft. long and 60 ft. span, and is served by a 10-ton overhead electric crane covering both road and rail entrances and exits, and is glazed over the whole roof area, and heated throughout.

All machines are of the most modern type, and are served by feed and delivery tables, so that production is carried out with a minimum of effort by the operator, and with the maximum efficiency, and are capable of dealing with high-tensile heat-treated steels from $\frac{1}{8}$ in. diameter up to $4\frac{1}{2}$ in. diameter, and other sections of equivalent sectional area. Of special interest is a multiple roll-straightening machine, built by W. H. A. Robertson and Co., Ltd. This machine is for straightening from coils black heat-treated steel from 55 to 65 tons tensile, in sizes from $\frac{3}{16}$ in. to $\frac{7}{16}$ in. diameter, or hexagons of equivalent strength and shearing these into any lengths required up to a maximum of 10 ft., at a speed of 100 ft. per min.

The straightening unit carries 16 staggered rolls in two groups of eight, each on horizontal and vertical rolls, respectively, and, in addition, a pair of pinch rolls on horizontal spindles are provided at the entry of the machine. All rolls on the machine are positively driven, and the top and outer rolls in each set are adjustable to provide the straightening effect.

The material, after leaving the straightening rolls, passes through the shears to the run-out table; this is provided with a movable stop carrying the automatic switch operating suitable electrical and mechanical devices, which cause the straightening rolls to stop and the shear to operate when the straightened length reaches it. When the straightened length has been sheared the table is automatically tilted to deposit the piece in the catchers provided; the table then returns, and the rolls restart. The whole machine is arranged for direct drive by an 8-h.p. motor at about 960 r.p.m.

In the warehouse lock-up and open bins are provided for the storage of bright and black bars to accommodate the large stock of all qualities of aircraft standard steels which are carried.

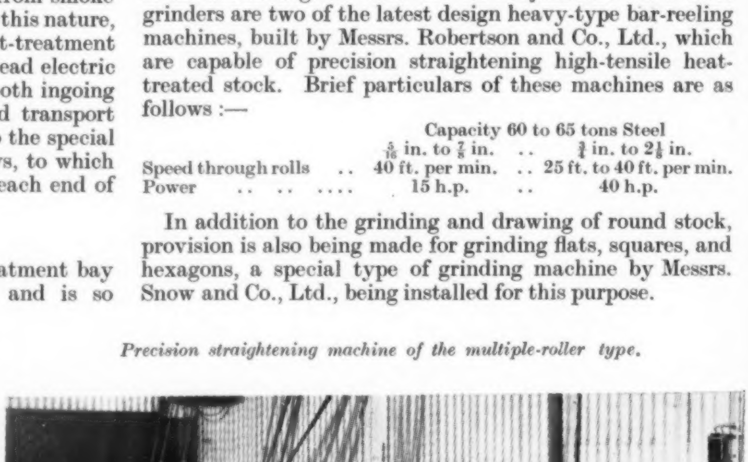
Centreless Grinding and Bright-Drawing Department.

Specially designed for the production of bright-ground and drawn bars in all qualities of alloy steels, this section is equipped with centreless grinding plant, comprising one No. 4, and one No. 5 Lidkoping centreless grinders capable of grinding bars from $\frac{1}{16}$ in. up to 4-in. diameter to precision limits in lengths up to 30 ft. The No. 4 centreless grinder is shown in Fig. 3. For use in conjunction with these grinders are two of the latest design heavy-type bar-reeling machines, built by Messrs. Robertson and Co., Ltd., which are capable of precision straightening high-tensile heat-treated stock. Brief particulars of these machines are as follows :—

	Capacity 60 to 65 tons Steel	
	$\frac{5}{16}$ in. to $\frac{7}{8}$ in. ..	$\frac{3}{4}$ in. to $2\frac{1}{8}$ in.
Speed through rolls ..	40 ft. per min. ..	25 ft. to 40 ft. per min.
Power	15 h.p. ..	40 h.p.

In addition to the grinding and drawing of round stock, provision is also being made for grinding flats, squares, and hexagons, a special type of grinding machine by Messrs. Snow and Co., Ltd., being installed for this purpose.

Precision straightening machine of the multiple-roller type.



Precision straightening machines of the multiple roller type by Messrs. Robertson and Co., Ltd., have been installed to work in conjunction with this grinder, as shown in Fig. 4. As will be appreciated, this machine is for straightening bright-drawn bars of heat-treated alloy steel in various tensiles up to 60 to 65 tons per square inch in hexagons up to 1 in. across flats, and other straight-sided sections of equivalent strength at a speed of about 80 ft. per min. It carries 12 staggered straightening rolls in two groups of six each on horizontal and vertical spindles, respectively, and, in addition, a pair of pinch rolls are provided at the entry of the machine. All rolls are positively driven, and half are adjustable vertically to provide the straightening effect. In addition to the individual adjustment of three of the rolls on vertical spindles, the framing carrying these rolls is adjustable horizontally as a whole, by means of which adjustment any size of hexagon bar (for which the machine is mainly used) can be dealt with in one set of rolls. It is arranged for direct drive by a 12-h.p. motor which is placed at the back of the rolls on the main bedplate.

The English Steel Corporation, Ltd. shortly expect to be in a position to supply precision-ground steels in all flat-sided sections and, when finally completed, the whole plant, with its entirely modern equipment, will meet the rapidly-increasing demand for both bright and black steel bars of any desired quality.

New British Chemical Standard—Aluminium Silicon Alloy "B"

The increasing use of aluminium alloys high in silicon, and the issue of A.I.D. and B.S.A. specifications for them, have justified the demand for a standard analysed sample of this type. British Chemical Standards headquarters has for some time been supervising the preparation and analyses of a new sample which is now ready for issue.

The standard turnings have been carefully analysed as usual by a number of experienced chemists representing the different interests, which include independent analysts, a Government department, manufacturers, and users, including chemists in France, Czechoslovakia and Norway.

The elements which are at present standardised are as follows :—

Si	12·74%	Zinc ..	0·020%
Fe	0·34%	Ti	0·006%
Mn	0·005%	Cu	0·010%

The standard figures for traces of other elements which are present may be issued and published subsequently.

To illustrate the great interest taken in this alloy by the co-operating chemists, one of the firms (Research Laboratory of the British Aluminium Co., Ltd.) has made no fewer than 90 determinations for silicon, and 57 determinations for iron by three independent operators. It is believed that this is the only standard of its kind issued in Great Britain, the U.S.A. or the Continent, and it is therefore likely to be of international interest.

The standard is issued in bottles containing 500 grms., 100 grms., and 50 grms., and each bottle is provided with a certificate showing the analyses of each chemist together with an outline of the methods used. In particular the methods for determining silicon will be of interest, as this element when present in quantity in aluminium alloys has presented some difficulty to analysts.

The standard is issued at a price which it is estimated will eventually cover the cost, and may be obtained from Messrs. Ridsdale and Co., 3, Wilson Street, Middlesbrough, or from any laboratory furnishers.

Water as an Engineering and Industrial Material.

The Ninth Edgar Marburg Lecture was delivered by Mr. S. T. Powell, at the recent annual meeting of the American Society for Testing Materials on the above subject in which he indicated that where broad specifications are acceptable, as in the majority of applications, no particular difficulty may be experienced. For the critical conditions, however, fundamental data are lacking, and our knowledge of many points is still very much in the twilight zone. Such a viewpoint is obvious when we pause to consider that we are dealing, not merely with a simple compound of hydrogen and oxygen, but complex chemical solutions, the composition of which is seldom accurately known. Until the recently-published studies of Braidech and Emery, few chemists or engineers, to say nothing of the general public, realised that many of our municipal water supplies contain lead, fluorides, and zinc in appreciable amounts, and that nickel, silver, boron, and other metals were also detectable in a number of drinking-water supplies, when the methods used for identification of these elements were sufficiently delicate.

While there is a natural tendency to ignore this factor as insignificant, Mr. Powell questions this attitude, since the data have been too meagre to interpret their significance correctly. It is interesting to note that, in at least one instance, traces of lead in a number of public water supplies were shown definitely to have resulted in endemic lead poisoning among consumers of such waters. The findings reported were the result of an investigation conducted by the Metropolitan Life Insurance Company. Manganese, when present in water in such small amounts as one part in three million is highly objectionable in dyeing, textile, laundry, and the non-alcoholic beverage industries.

In the lecture Mr. Powell described the modern methods of testing and analysing water and its deposits, including the petrographic, spectrographic and the recently-developed polarographic methods. He discussed the embrittlement of boiler steel, indicating the heavy losses from this source. Briefly, he said, caustic embrittlement is the destructive chemical attack by caustic soda on the boiler steel under stressed conditions, and may occur when boiler-water salines contain high concentrations of caustic soda and relatively low concentrations of sulphates. The prevention of this form of destructive action is so relatively simple that it is difficult to conceive why these costly failures should continue to develop. Adequate protection will be effected by the maintenance at all times of specific ratios of sodium sulphate to total alkalinity.

Engineers look forward to the time when 15 minutes will be considered reasonably rapid in determining the creep rate of metal. Steel which will creep 0.001 inch in 10 years will creep approximately 0.0001 inch in one year, 0·00001 inch in one month 0·0000003 inch in one day, 0·00000001 inch in one hour, and 0·000000003 inch in 15 minutes. This means that to predict this creep by a 15-minute test it is necessary for the physicist to develop apparatus which can distinguish a stretch of three billionths of an inch in a one-inch sample of steel. Engineers of a large electrical manufacturer have developed analytical methods and apparatus which reduce the duration of creep tests from three months to one month. New methods and apparatus now being developed may reduce the time of tests to only one hour.

Use of 18–8 chrome-nickel corrosion-resisting steel as a light-weight structural material is a recent development. This alloy, being austenitic, may be hardened materially by cold working and this property, which usually has been regarded as detrimental, has been used advantageously for the production of cold-rolled light-gauge strip with tensile strength of 150,000 to 180,000 pounds per square inch. By suitable fabrication methods, this has been formed into structural members of great strength and rigidity, the non-corrosive properties of the metal making them permanent. Such material is used in airplanes, railcars and motor buses, and results in a saving of weight in railway passenger coaches of 75% or more, which provides considerable economy in operating charges.

Reviews of Current Literature.

Arsenical and Argentiferous Coppers.

The development of knowledge in all branches of science, and especially in chemistry, has been so rapid during the last 50 years, and the fields covered by this development have been so varied, that it is difficult for any individual to keep in touch with the progress in branches of science outside his own speciality. In spite of the facilities now available, it often takes a great deal of time to co-ordinate the knowledge available upon a single topic. Consequently, when men who have spent years in the study of important subjects are willing to co-ordinate their knowledge and present it in concise, readable form, they perform a service of the highest value. The recognition of the usefulness of reviews of this character caused a Committee of the American Chemical Society to recommend the publication of two series of monographs. This course was arranged with the Interallied Conference of Pure and Applied Chemistry, which met in London and Brussels in July in 1919, and a large number of monographs have been published. The volume on arsenical and argentiferous coppers is a further addition to the series, and metallurgists generally will owe a debt of gratitude to the technical staff of the Battelle Memorial Institute for preparing it, and the executives of the Calumet and Hecla Consolidated Copper Co. for supporting the work and making it possible.

In reviewing this work the foreword by Mr. H. Foster Bain so admirably agrees with our views that we cannot do better than abstract from it. In the preparation of this monograph it has been regarded as sufficient merely to point out the special properties of the argentiferous and arsenical coppers, but as a background for the understanding of these there has been compiled a general account of copper itself in all its phases. It constitutes one of the most authentic and complete, as it is certainly the most up to date of compendiums on the properties and uses of the metal. It is very doubtful indeed whether so much modern knowledge of this ancient metal, and in so few pages, can be found elsewhere.

In addition, however, the work is not only a review of previous knowledge regarding the effect of additions of silver and arsenic, but of many new technical data based upon accurately made tests by modern methods. Copper, silver, and others of the metals which have long been in the service of mankind have in a sense suffered in the recent intensive competition among metals because of the very fact that they have been known so long. Many of the technical data available regarding them have been handed down from the past and rest ultimately upon empiric results. The late-comers in the field, having no such accumulated lore, have necessarily been intensively studied by the refined methods of modern research. This gap in our knowledge as regards an important group of the coppers has now been filled. The researches presented have brought out the special adaptability of these coppers in several important fields.

Among the results here presented for the first time, or here thrown into adequate and sharp relief, may be mentioned those dealing with the effect of arsenic on the properties of tough-pitch copper in both the cold-rolled and the annealed condition, and the effects of increasing amounts of silver on the softening of cold-rolled copper during tinning. These results certainly warrant the careful attention of metallurgists and copper users.

The book is admirably prepared, well illustrated, and possesses a useful bibliography, and it is a pleasure to commend it to the reader interested in copper and its uses, to whom it will prove invaluable.

By J. L. Gregg. Issued by The Chemical Catalog Company, Inc., New York, U.S.A. Price $4.00.

Desulphurisation of Pig Iron.

The elimination of sulphur from pig iron is an important feature of blast-furnace practice, and bears directly upon production costs. Results on two phases of desulphurisation are reported by Messrs. T. L. Joseph and W. F. Holbrook.[1] One investigation has involved a study of the effect of temperature on the desulphurising action of manganese, independent of slag reactions, and the other has been concerned with the effect of replacing lime with magnesia upon the desulphurising action of blast-furnace slags.

In laboratory tests the authors show that metal containing several tenths of 1% of sulphur can be desulphurised by allowing the metal to cool, provided the residual manganese approximates 2·0%. A small amount of manganese will be lost as manganese sulphide. The product, per cent. Mn times per cent. S, approaches a constant value at a given temperature. Normal variations in silicon and manganese have little effect upon the constancy of this product. From the data obtained the sulphur content of the metal between 1,250° C. and 1,500°C. can be predicted for any manganese content. The effect of temperature is more pronounced above 1,350° C., but a change of 25° C. has a significant effect at temperatures little above the melting point of cast iron. Mechanical contamination of cast metal can be prevented by removing the solid layer of manganese sulphide and kish, and skimming the metal during pouring.

The possibilities of depending less upon slag-metal reactions for desulphurisation, and more upon the use of high-manganese iron in plants using high-sulphur coke are outlined briefly. Small-scale tests indicate that low-sulphur metal and a roasted product, suitable for producing ferro-manganese, can be produced by treating high-phosphorus spiegel with iron sulphide. Tests of the effect of replacing CaO with MgO on the desulphurising power of blast-furnace slags indicate that CaO is a somewhat more active sulphur scavenger. The decreased desulphurising power of the slag was very pronounced beyond 10% of MgO when the molar basicity was held constant. A substitution of MgO for CaO on a percentage basis (per cent. $CaO + MgO$/per cent. $Sio_2 + AI_2O_3 = 0{\cdot}91$) decreased desulphurisation. This decrease was considerably less, however, than that produced by lowering the temperature 50° C.

Improvement in quality of chromium plate has been the natural result of intensive study by electrochemists both in automotive laboratories and by parts manufacturers, and by the realisation that a good job costs little more than a poor one. A continued campaign of education has emphasised the importance of many essential factors, such as preliminary cleaning and buffing, sufficiently generous underplates of copper and nickel, and proper control of the chromium tank as to solution, temperature, current density and arrangement of work. One automobile manufacturer measures the thickness of the coatings on a polished cross-section in addition to using the salt-spray test.

A proprietary composition for non-metallic moulds of the so-called permanent type is composed of three parts of chrome ore, one part of fused silica, and one part of bentonite. The materials are ground finely, mixed with water and then rammed into mould form. The mould is baked under gradually increasing temperature until the latter exceeds 1,800° F. for several hours. After cooling, the mould is examined and corrected for accuracy. Before use, the mould surface is coated with finely ground clay suspended in sodium silicate, dried, and then coated with lampblack. The latter coating is repeated between casts.

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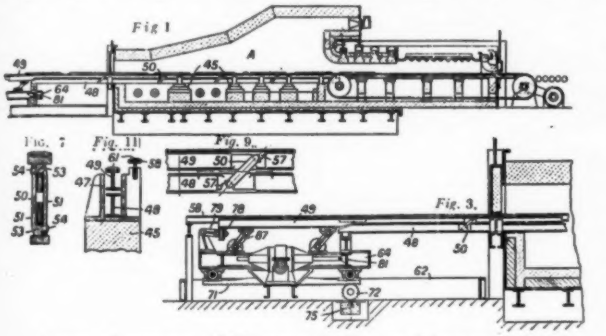
1 U.S. Bureau of Mines Report of Investigations, 3240.

Some Recent Inventions.

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Conveyer Mechanism in Heat-treating Furnaces.

Much of the development achieved in heat-treating operations can be attributed to various methods adopted during recent years which convey the parts treated through the heating zone. There are many mechanical means available for the accomplishment of this operation, and a recent development of this type the conveyer mechanism of which operates on a step-by-step principle is of considerable interest. In this development the work is conveyed step by step through a furnace chamber, Fig. 1, by movable



A type of conveyer which operates on a step-by-step principle.

rails 49 arranged between fixed rails at 58, which form the bed of the chamber, the rails 49 being moved vertically to lift the work without sliding on the bed, then horizontally to carry the work a step forward, then vertically downward to deposit the work in the new position on the bed, and then back to their original position. For this purpose the rails 49 are supported by sets of parallel links 50 on rails 48, so that relative horizontal movement of the rails 48, 49 raises or lowers the rails 49. The rails 48 are movable horizontally through channelled members 47, Fig. 11, supported on a series of piers 45 in the furnace chamber. The rails 49 are connected through a cross-beam 78, and links 79 to a carriage 64 which is moved to and fro on rails 62 by the engagement of racks 71 on the carriage with pinions 72 driven through gearing by a motor on the shaft 75. The rails 48 are connected with a second carriage 81 which is movable along the carriage 64 by screw-and-nut gearing driven by a motor on the latter, the two motors being controlled so that the carriage 81 is moved to raise the rails 49, and the carriage 64 is then moved to shift the rails 48 and 49 without relative movement between them. Links 87 connecting the rails 49 to the carriage 81 are equal and parallel to the links 50. The rails 58, 49 have work-engaging surfaces 61 of refractory material to prevent pitting. The links 50, Figs. 7 and 9, consist of two similar parts 51 having wedge-shaped ends 53 which extend through the webs of the rails and rest in grooves provided on the flanges of the rails at 57, and the ends 53 of the link members are formed with projecting pins 54 by which the two members 51 are secured together.

401,857. British Furnaces Ltd., and P. Hopkinson, Derby Road, Chesterfield. November 23, 1933.

Refining Steel.

In a process for dephosphorising steel by means of a molten oxidising basic slag, the slag is used in such fluid condition and the slag and molten steel are subjected to such turbulence that an emulsion-like mixture of metal and slag is produced. The process may be carried out by pouring the molten steel in a thick jet from a considerable height on to the slag or by pouring the steel rapidly into a receptacle, such as a ladle, at the same time as the slag. The metal, after treatment, may be treated again in a similar manner with the slag. In carrying out the process in a converter, the steel is dephosphorised in the usual manner, the blast stopped and the oxidised slag removed. A molten fluid oxidising basic slag is now charged over the steel and the blast resumed for a short period to effect turbulent intermixing previous to running. A slag comprising 3% by weight of silica, 65 of lime, 20 of iron oxide and 12 of fluorspar is referred to.

405,633. Soc. d'Electro-chimie, d'Electro-Metallurgie, et des Acieries Electriques d'Ugine, 10, Rue du General Foy, Paris.

Furnace Conveyer Improvements.

Another improvement concerned with the conveyance of articles through a furnace has been designed mainly in connection with furnaces for medium temperature work, the object being to provide an arrangement which is efficient and reliable in use, and at the same time relatively cheap in construction, avoiding what are claimed to be inconveniences and disadvantages of the well-known walking-beam type of furnaces, in which static members have to be independently supported between the moving members, necessitating mechanical sealing devices and other auxiliary fittings, and also rendering the construction complicated and costly.

In this device the furnace possesses upper and lower chambers which are separated by a longitudinally-slotted arch or hearth, and arrangements are made by which the articles under treatment in the upper chamber are conveyed through it by means of supporting fingers projecting

Fig 1

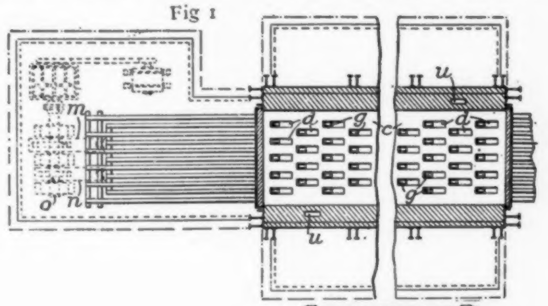
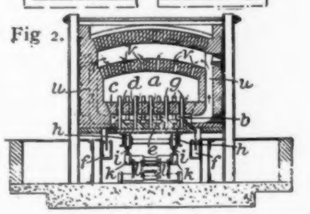


Fig 2.



Conveying improvements designed mainly for medium temperature work.

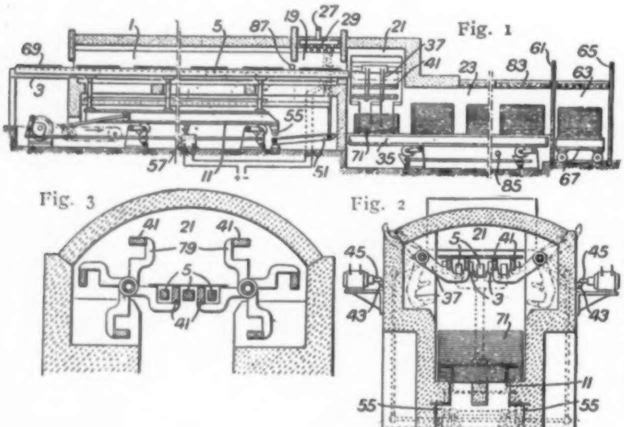
from a carriage in the lower chamber. The carriage is designed to provide combined reciprocating and rising and falling movements, during which the fingers are maintained in a supporting upper position during the intermittent forward traversing movement of the carriage, and cease to support during the alternating return traversing movement of the carriage. A further feature of this improvement is that the upper and lower chambers are adapted for an intercirculation of heating gases through the perforated hearth, and for recirculation of these gases from the lower to the upper chamber by way of interconnecting side ports and flues. The illustrations Fig. 1 and 2 show part-sections of a furnace incorporating the improvements and designed for heating metal plates, sheets, etc. It is provided with a conveyer device for imparting a step-by-step forward movement to the articles, the hearth *c* of the heating chamber *a* is formed with longitudinally and transversely-spaced slots *d*, through which are adapted to project fingers *g* mounted on a carriage *e* disposed below the hearth. The wheels *h* of the carriage run on short rails *i*

secured to longitudinal girders k, the carriage and the girders being separately reciprocated by pivoted levers m, n actuated by eccentrics on a motor-driven shaft o. Vertical movement of the girders k, and consequently of the carriage e and fingers g, is effected by rocking-lever mountings l. The fingers g, may, during their conveying stroke, either actually support the charge or be so shaped as to project upwardly between rows of articles, such as bars or tubes, and cause them to roll or slide along the hearth. The space b between the hearth c and the carriage e is shut off from the atmosphere by oil seals f, and side-wall flues u and ports v in the furnace crown are provided to permit the return to the heating chamber a of the gases which enter the space b through the slots d.

400,185. Alfred Smallwood and John Fallon, both of British Mills, Smethwick, near Birmingham. October 18, 1933.

Normalising Furnaces.

Considerable developments continue to be effected in various types of furnaces, the main objects desired being a high degree of precision in operation to suit the range of products for which they are designed. A recent development deals with a continuous normalising and annealing furnace for steel sheets, tin plates, or trays of small articles. These articles are conveyed singly through a normalising chamber 1, shown in the accompanying illustration, Fig. 1, and are then transferred to and stacked in piles in an annealing chamber 23. The annealing is effected during the travel of the piles through the chamber 23, by the heat taken up in the normalising treatment. As shown, the chambers 1 and 23 are fitted with conveyers 3 and 35 of the longitudinal beam step-by-step type, while, in the immediate transfer chamber 21 there is provided a pair of pivoted frames 37 adapted when in the raised position, to receive sheets etc., 69 from the conveyer 3, and to be swung downwardly to deliver them to a pile 71 on the annealing conveyer 35. The frames 37 have bars 41 constituting extensions of the fixed bars 5 of the conveyor 3 and are released to deposit a sheet on the pile 71 when a switch 57 is actuated by the rearward movement of the conveyor carriage 11 to withdraw electrically-operated detents 45 with which, when the frames 37 are in raised position arms 43, carried thereby, engage. As the carriage 11 moves forwardly, the switch 57 is actuated to reset the detents 45, and, by engagement of rollers 55 with levers 51, the frames 37 are raised to receiving position. The frames 37 may be replaced by a single frame mounted on a transverse pivoted shaft arranged either across the middle of the frame or at one end thereof. Fig. 3 shows a further construction in which the transfer device comprises a pair of rotary members each having four arms 79 carrying the supporting bars 41. At the end of the normalising chamber 1 is a pre-cooling chamber 19 having a hollow roof with ports 29 through which cooled waste gases supplied by a pipe 27 are directed on to the sheets. The annealing chamber 23 has its roof, and if desired, its walls and floor, water-cooled as shown at 83, while non-oxidising gases, withdrawn from the chamber 1 at 87, and cooled and dried, are supplied at 85. The piles 71 are delivered from the conveyor 35 to a truck 67 in a discharge-chamber 63 closed by doors 61, 65.



A continuous normalising and annealing furnace.

409,034. A. W. O. Webb, Denman Drive, Golders Green, London.

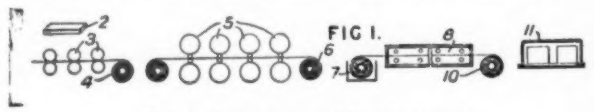
Coating with Metals.

Continuous coatings of molybdenum are applied to articles of other materials, *e.g.* iron or nickel, by applying to the article a thin coating of a molybdenum compound in a colloidal state and heating in a reducing atmosphere at over 900° C. Colloidal molybdic acid formed by heating crystalline ammonium molybdate *in vacuo*, is a suitable compound. The coated articles are suitable for medical apparatus, and internal parts, such as support wires, of gas-filled electric incandescent or glow discharge lamps. In the lamps the molybdenum prevents the release of gaseous impurities from the cores, and absorbs gaseous impurities in the filling.

402,916. General Electric Co., Ltd., Magnet House, Kingsway, London.—(Assignees of Patent-Treuhand-Ges. für Elektrische Glühlampen; 11, Ehrenberg-strasse, Berlin.)

Heat-treating Silicon Steel.

Althouxh the use of straight silicon steels is somewhat confined, the question of their heat-treatment is important. A new method developed for treating these steels, especially those containing 0·3 to 6·0% silicon, is therefore noteworthy. The object is to improve their electrical properties, and in this method a hot-rolled strip is subjected to a cold-working operation to reduce its thickness and introduce excessive strain therein, is then heat-treated to remove partially the said strain, and then annealed and/or treated so as to preclude any substantial coil set in the finished product. The cold working is carried out to obtain a minimum reduction of approximately 10%, and the time



Illustrating sequence of heat-treatment.

and temperature of the heat-treatment is varied according to the silicon content of the steel, or to the amount of reduction produced by the working. A billet 2 is subjected to hot rolling by rolls 3 and the strip so produced is formed into a coil 4. The strip is then subjected to cold rolling by rolls 5 to produce the excessive strain therein and is formed into a coil 6. The coil is then placed in a box 7, fed through a furnace 8, preferably maintained at a temperature of 1,900° F., at a predetermined rate and coiled at 10. The coils are then annealed in a box 11 at a temperature of 1,500–1,700° F., or the strip is cut into sheets which are then box annealed. To preclude coil set in the final product the hot-rolled strip, in the form of a coil, is box annealed and then passed through the heat-treating furnace, being coiled after this treatment at some distance away from the furnace so that the strip, before coiling, will have cooled to such an extent that it will have substantially no coil set after coiling. The material may be passed through rolls before entering the furnace for the purpose of introducing the strain therein.

409,310. E. M. Freeland, Ohio Avenue, Youngstown, Ohio, U.S.A.

Business Notes and News

Drill Steel Drawback.

The Import Duties Advisory Committee, in a recent report, recommend the allowance of drawback under Section 9 of the Finance Act, 1932, in the case of hollow mining drill steel in respect of the billets of steel used in the manufacture thereof. Effect was given to this recommendation by the Import Duties (Drawback) (No. 10) Order, 1933, which was due to expire after a period of one year from August 4, 1933, the date on which the order came into operation. In a report issued as a White Paper the Committee state :

" We have received representations that the detailed specification in this order has become restrictive. In certain fields the use of special alloy steels is being developed, and in quoting for orders for these steels it is not possible for the applicants, by reason of the detailed analysis set out in the present scheme, to take advantage of the drawback facilities.

" In our previous recommendation we expressed the hope that by the end of the operation of the present scheme the quality and suitability of drill steel produced from Sheffield billets would be sufficiently established to enable the export trade to dispense with the help of drawback. Although some progress has been made in this direction a preference still exists in important cases for Swedish material, and the termination of the drawback scheme would handicap British manufacturers in tendering for contracts in which imported material is specified. We are satisfied that it is in the national interest for drawback to be continued for the time being, and for the scheme to be modified to bring within its scope the special alloy steels now being used.

" An essential characteristic of all the steels used is the relatively low percentage of sulphur and phosphorus, and the material has accordingly been defined by reference to the content of these impurities."

The Committee conclude that drawback should be allowed in future in respect of the quantity of material used in the manufacture of, rather than in respect of the amount contained in, the exported drill steel, and they recommend that drawback should be allowed in respect of the average quantity of the material used by manufacturers generally in the manufacture of hollow mining drill steel ; that is to say, 1¼ tons of billets of steel per ton of hollow mining drill steel, exclusive of the weight of the stainless steel lining, if any.

The rate of the drawback shall be £2 10s. per ton weight of the material aforesaid. The drawback shall not be allowed in respect of the material imported before August 4, 1933, or after August 3, 1934. Subject to this, the drawback shall be allowed for a period of six months from August 4, 1934.

World's Largest Propellers.

The first propeller for the giant Cunarder has been despatched from the Millwall (London) works of the makers, the Manganese Bronze and Brass Co., Ltd. The ship will be fitted with four working and four spare propellers, which have been made jointly by the above-named firm and J. Stone and Co., Ltd., of Deptford. They are the heaviest manganese-bronze castings in the world, and the largest propellers ever made. They weigh about 35 tons each. The final process in their manufacture was the statically balancing, in which such a degree of accuracy was attained that the slightest finger pressure applied to a blade was sufficient to set the propeller in motion. The job of producing the set of propellers has occupied about six months.

Copper Sulphate Plant to be Closed Down.

Information received indicates that the Mond Nickel Co., Ltd., are closing down the copper-sulphate plants at their Clydach (Swansea Valley) works. It is stated that during the past few years the disposal at an economic price of such quantities of copper sulphate as are indicated has become increasingly difficult, mainly on account of the ever-increasing duty and quota restrictions imposed on its importation into the countries concerned.

Unfortunately, the decision to close the refinery will mean that the services of a considerable number of men at Clydach will have to be dispensed with, and it is a sincere regret to the Company that this is unavoidable. However, earnest consideration is being given to this aspect of the problem, and it is hoped that it will be found possible to find a satisfactory solution.

Metropolitan-Vickers Contract.

The Victoria Falls and Transvaal Power Co., Ltd., has placed another important contract for generating plant to be installed in the new Klip River Station, South Africa, with the Metropolitan-Vickers Electrical Co., Ltd., of Trafford Park, Manchester. The contract covers the supply of three turbo-alternator sets, each of 33,000 k.w. capacity, complete with condensing plant.

Three units of similar capacity were supplied to the Victoria Falls and Transvaal Power Co. for their Vereeniging power-station some years ago. The whole of the plant under the present contract will be manufactured at the Trafford Park works of the Metropolitan-Vickers Electrical Co., Ltd.

Large Rolling Mill Bearings.

Claimed to be the largest ever made, the first of four 3-ton tapered roller bearings, for the Renault rolling mills in France, has been subjected to running tests at the British Timken works. For test purposes the bearings are run in under a load of 200 tons at 42 r.p.m. for a period of 8½ hours. The four bearings each weigh 3¼ tons, and are 4 ft. 3 in. in diameter. With a further 64 tapered roller bearings of various sizes they constitute the complete bearing equipment for a new steel rolling mill, which is to be erected at the Renault motor works in France.

The placing of the order for these bearings with British Timken, Ltd., followed successful results already obtained with bearings in use in Germany, Italy, Spain, Russia, and other countries. Several new mills recently erected in this country have also been equipped with tapered roller bearings. A noteworthy sign of the general optimism prevailing in the engineering trades, it is said, is the fact that sheet producers are looking to their plant and installing the most modern and efficient equipment.

Mr. W. Dallow, managing director of British Timken, Ltd., said economic nationalism was resulting in the creation of all manner of engineering plants abroad, but it was significant that Britain was still receiving a great number of engineering orders from overseas. He was confident that more engineering contracts were coming to this country just now than had been coming for a considerable time past. It must not be imagined that sheet-metal producers in this country were idle while advance was taking place abroad. He noticed the other day a suggestion that the rolling mills of this country had been allowed to fall behind the times and that nothing was being done to alter that position. That idea was quite wrong. The rolling mills in South Wales, in Sheffield and South Yorkshire, in the Glasgow area and along the North-East Coast had had a very bad time during the past few years, but they had never lost sight of the need for maintaining the traditional efficiency of their plants. They had steadily improved these plants as trade conditions had allowed.

Sale of Palmer's Steelworks.

Following the information recently published regarding the purchase of Palmer's shipbuilding yard at Jarrow by National Shipbuilders' Security, Ltd., comes the information that the blast furnaces and steelworks at Jarrow, covering about 35 acres, fronting the River Tyne, have been acquired by the Sheffield firm of Thos. W. Ward, Ltd.

Whether these works will share the fate of the shipyard and be sold piecemeal is not disclosed, but in view of the recent activity in the steel trade, and for the sake of local industry, it is to be hoped that some scheme might be devised whereby this will be avoided.

Technical Education in Great Britain.

" The progress of technical instruction in this country," states Mr. I. J. Pitman, M.A., who has been appointed chairman and managing director to the new public company into which the Pitman publishing firm has just been converted, " has won the admiration of all who are acquainted with it, and especially of visitors from overseas, who are inquiring into questions of this kind. I feel that no small tribute for this success is due to the authors and publishers of technical books."

Mr. I. J. Pitman added that his own firm was particularly interested in the publishing of new technical books, and that manuscripts from technical writers on all up-to-date subjects received the fullest consideration.

Recent Orders for Castings

Amongst recent orders Messrs. Kryn and Lahy (1928), Ltd., Letchworth, Herts., have obtained a large contract for a total weight of 120 tons of miscellaneous castings from a well-known rolling mill corporation. Some of the items will be of mild steel, some of high-carbon steel, and the remainder of the well-known K.L. "Stronger Steel." The latter has the strength of 35-ton steel with the ductility of 26-ton steel, and is invaluable where lightness with great strength is desired. The makers of this steel guarantee a tensile strength of 35–40 tons per square inch, with an elongation of 20% minimum and a cold test bend of 120°. It is interesting to note that this contract follows on several others from the same corporation.

Overseas Railways Equipment.

Contracts for equipment for overseas railways issued recently include orders awarded by the Crown Agents for the Colonies to Wright's Ropes, Ltd., of Birmingham, for the steel structural work and steel ropes, respectively, for a 325-ft. suspension bridge over the River Prah, Gold Coast.

The Union of South Africa Railways and Harbours Administration has placed orders with Metropolitan-Cammell-Weymann Motor Bodies, Ltd., of Saltley, Birmingham, for all-metal omnibus bodies. Orders for Indian railways comprise 85,000 bolts and nuts from Guest, Keen and Nettlefolds, Ltd., Birmingham, and Egyptian State Railways has placed orders with the "Sentinel" Waggon Works, Ltd., of Shrewsbury, for ten articulated steam-rail cars at a cost of £66,300.

Soviet Scientists to Study Far East.

A group of scientists from the Academy of Sciences of the U.S.S.R. is leaving for the Far East this summer, in order to investigate various questions of economic and scientific importance. They will carry out research in the Burya coal basin, and decide various questions concerning the building of a metallurgical combine in the Khingan district. They will also make a study of the Zeya or district lying in the south of the Mongol-Okhotsk region.

The group consists of Academicians Komarov and Fersman and Professors Nalivkin, Lebedev, Slavyanov and Sumgin. The group will also visit Khingan, the Lower Amur, and other regions of the Far East.

Magnitogorsk's New Rolling Mill.

A new rolling mill—the "500,"—said to be the largest in Europe, is under test at the Magnitogorsk metallurgical plant, and is to be put into operation during this month. The annual output of the mill is estimated at 320,000 tons. The entire process of the "500" is mechanised, control being concentrated in 19 electric switches, by means of which the giant plant, with its nine sets or trains of rolls and five shears, is set in motion. The electric equipment has been produced, for the most part, by the Electrosila plant in Leningrad.

With the starting of the new mill the output of the Magnitogorsk rolling mill shop will be practically doubled. (The combine now produces 4,000 tons of pig iron and 1,000 tons of rolled products daily.) The variety of rolled products turned out by the plant is also to be increased; it will include I-beams, rails, channel, angle, round, square, and bar iron. The engineers of Magnitogorsk do not anticipate any difficulties in mastering the "500," although it has auxiliary appliances new to Soviet experience.

Obituary.

We regret to record the death, on July 21, of Mr. W. H Bassett, and of Dr. Karl Meissuer. Mr. Bassett was the recently-elected President of the American Society of Testing Materials. He was 66 years of age, and a pioneer metallurgist in the non-ferrous metal industry. His early and sustained work in the copper and mass industry probably did more than that of any other to place the industry on a scientific and technical basis. He introduced in the United States the use of microscopy in the metallurgy of non-ferrous metals, and was among the first to apply the spectroscope to routine work in the non-ferrous industry. He was metallurgical manager of the American Brass Company, Waterbury.

Dr. Karl Meissuer was research metallurgist to the Dürener Metallwerk, Düren, Rheinland, the originators and present German producers of duralumin. He was well-known in England as the German duralumin expert, and was a familiar contributor to the papers and discussions at the Institute of Metals. He was 40 years of age.

Forthcoming Meetings.

(*Continued from page* 1C4.)

III.—Pounding Tests," by H. Greenwood, M.Sc.; "Some Properties of Tin Containing Small Amounts of Silver, Iron, Nickel, or Copper," by Professor D. Hanson, D.Sc., E. J. Sandford, B.Sc., and H. Stevens, M.Sc. If time permits: "A Reflectivity Method for Measuring the Tarnishing of Highly Polished Metals," by L. Kenworthy, M.Sc., A.R.C.S., and J. M. Waldram, B.Sc., A.C.G.I.; "The Corrosion of Tin and Its Alloys. Part I.—The Tin-Rich Tin-Antimony-Copper Alloys," by T. P. Hoar, M.A., Ph.D.

September 5: "The Influence of Pickling on the Fatigue-Strength of Duralumin," by H. Sutton, M.Sc., and W. J. Taylor; "Some (Magnetic) Properties of Heavily Cold-Worked Nickel," by H. Quinney, M.A.; "Experiments in Wire-Drawing. Part IV.—Annealing of H.-C. Copper Wires of Varying Hardness—Elongation Values," by W. E. Alkins, M.Sc., and W. Cartwright, O.B.E., M.Sc.; "The Crystal Densities of Industrial Brasses from X-ray Data," by Professor E. A. Owen, M.A., D.Sc., and Llewelyn Pickup, M.Sc., Ph.D.; "Elongation Values of Copper and Copper-Rich Alloys," by Maurice Cook, M.Sc., Ph.D., and Eustace C. Larke. If time permits: "Crystal Re-Orientation on Heating Drawn Copper Wires." by G. S. Farnham, B.A., M.Sc., and Hugh O'Neill, M.Met., D.Sc.

Further papers to be presented at this meeting include the following: "Deformation Lines in Alpha Brass," by Carl H. Samans, Ch.E., M.S.; "The Spectrographic Detection and Estimation of Minute Quantities of Impurities in Copper," by M. Milbourn, B.Sc.; "The Spectrographic Analysis of Some Alloys of Aluminium," by H. S. van Someren, B.Sc.; "A Synthetic Spectrum Method of Analysis and Its Applications to the Quantitative Estimation of Small Quantities of Bismuth in Copper," by D. M. Smith, A.R.C.S., B.Sc.; "A Note on Some Ancient Copper-Coated Silver Coins of Cyprus," by Stanley G. Willimott, B.Sc., Ph.D.

Many interesting works visits have been arranged in connection with this meeting.

INSTITUTE OF MARINE ENGINEERS.

Sept. 11. Presidential Address by Mr. John H. Silley, O.B.E., at the Institute premises, The Minories, London, E.C. 3. The chair will be taken by Mr. J. Hamilton Gibson, O.B.E., M.Eng., at 6 p.m.

Catalogues and Other Publications

"Silver Fox" stainless steels have been designed to overcome many of the difficulties associated with the use of stainless steels, particularly as regards ease of manipulation and resistance to the attack of various types of corrosion and to weld-decay. These stainless steels are made by the high-frequency electric process, are uniform in structure, and remarkably free from non-metallic inclusions, according to a copy of a catalogue recently received, which contains information of interest and value. The notes on soldering, brazing, and welding appearing at the end of the catalogue are of particular interest, and readers should obtain copies from The United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, 10.

A. C. Wickman Ltd., Coventry, have recently prepared an attractive folder giving information regarding the "Wimet" tipped inserted blade milling cutters which have been designed to incorporate the vital points necessary in efficient cutters. It illustrates some of the applications of this milling cutter and discusses briefly its leading features.

Following the publication of the pamphlet AA 1, entitled "Recommended Materials for Automobile Transmission," the Mond Nickel Co., Ltd., have now issued two further leaflets in this series—Nos. AA 2 and AA 3,—giving recommended materials for automobile engines and automobile front axles, chassis and fittings, respectively. Copies of these should be obtained from Bureau of Information on Nickel, Thames House, Millbank, London, S.W. 1.

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‡Ferro Tungsten	,,	0 3 0
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§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	,,	34 5 0
Guar. max. 1% Carbon, scale 12/6 per unit	,,	36 10 0
§Guar. max. 0·7% Carbon, scale 15/- per unit	,,	39 2 6
‡Manganese Metal 97-98% Mn.	lb.	0 1 4
‡Metallic Chromium	,,	0 2 5
§ Ferro-Vanadium 25–50%	,,	0 12 8
§ Spiegel, 18–20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	6 5 0
20/30% basis 25%, scale 3/6 per unit	,,	8 2 6
45/50% basis 45%, scale 5/- per unit	,,	11 17 6
70/80% basis 75%, scale 7/- per unit	,,	18 10 0
90/95% basis 90%, scale 10/- per unit	,,	28 17 6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	,,	13 15 0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20–25%	ton	15 6 0
§ Ferro-Molybdenum, Molyte	lb.	0 5 6
§ Calcium Molybdate	,,	0 5 4

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S. Wales	—	1 5 0
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Crown Bars	9 12 6
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†10% Phos. Cop. £30 above B.S.
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Foundry No. 1	3 12 6
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Hematite No. 1	3 8 0
Foundry No. 1	3 10 0
,, No. 3	3 7 6
,, No. 4	3 6 6
Silicon Iron	3 10 0
Forge	3 6 6
Midlands—	
N. Staffs Forge No. 4	3 7 0
,, Foundry No. 3	3 11 0
Northants—	
Foundry No. 1	3 10 6
Forge No. 4	3 2 6
Foundry No. 3	3 7 6
Derbyshire Forge	3 6 0
,, Foundry No. 1	3 14 0
,, Foundry No. 3	3 11 0
West Coast Hematite	3 7 0
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Billets Kr. 240-290 £13 10 0–£16	0 0
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Rolled Charcoal Iron Bars Kr. 290	16 0 0

All per English ton. f.o.b. Gothenburg.

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Copper Clean	£25 0 0
,, Braziery	22 0 0
,, Wire	—
Brass	18 0 0
Gun Metal	23 10 0
Zinc	9 0 0
Aluminium Cuttings	69 0 0
Lead	10 0 0
Heavy Steel—	
S. Wales	2 14 0
Scotland	2 10 0
Cleveland	2 10 0
Cast Iron—	
Midlands	2 7 6
S. Wales	2 7 0
Cleveland	2 12 0
Steel Turnings—	
Cleveland	1 17 6
Midlands	1 13 0
Cast Iron Borings—	
Cleveland	1 7 6
Scotland	2 0 0

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,, ,, (Marine) ,,	—
,, ,, (Land), N.E. Coast	8 10 0
,, ,, (Marine) ,,	8 17 6
Angles, Scotland	8 7 6
,, North-East Coast	8 7 6
,, Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 10 0
Light Rails £8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic £6 17 6 to	7 2 6
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Standard Cash	£229 0 0
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Tin Plates I.C. 20 × 14 box	18/-

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§ Prices quoted August 13, ex warehouse.